Manufacturing

Allis-Chalmers Company

Mining and Crushing Machinery Department

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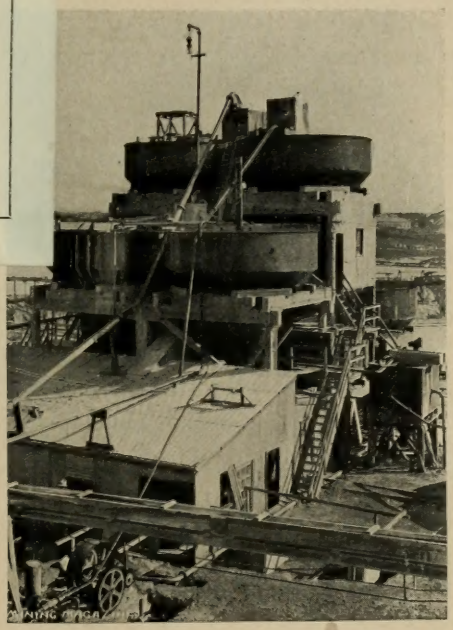
Cyanide Plants and Their Equipment



MILWAUKEE, WISCONSIN, U. S. A.

By Allis-Chalmers Co.

Cyanidation.

The cyanide process is based upon the principle that dilute solutions of cyanide of potassium will dissolve gold and silver under certain conditions, and, while there are limitations to its use, its application has been greatly broadened since the first few years following its introduction in the mining industry, until now the process is one of the most important known to metallurgy. It is particularly adapted to certain classes of ores which, owing to their low grade character and other features, physical, chemical and mineralogical, are not treatable by other processes, at least on a commercial scale; such ores were, it seems, destined to remain in nature's keeping until the advent of this process, which gives promise of extension to such fields and such ores as were formerly never dreamed of by its most enthusiastic advocates. So it is that we now have a wet chemical process whose practical application is understood and whose position in metallurgy is not only firmly established but is actually threatening the very existence of other and older processes and in many places superseding them.

THE PROCESS INVOLVES FOUR DISTINCT OPERATIONS.

In the simplest application of the cyanide process ore undergoing treatment is first crushed to the proper degree of fineness, and then charged into leaching vats, where contact is had with a dilute solution of cyanide of potassium. When the gold and silver is dissolved, the solution is drawn off the ore through a filter bed, thus clarifying it, and thence conducted to precipitating boxes or tanks (filled with zinc shavings), where the gold and silver is extracted and later recovered in the form of a marketable product or bullion. Thus it will be seen that the process consists essentially of four operations:

1. Preparation of the ore.
2. Dissolving of the precious metal contents by cyanide of potassium solution.
3. Precipitation of the dissolved gold and silver.
4. Recovery of the precipitated gold and silver.

DIFFERENT CYANIDE PROCESSES.

Our remarks so far have been made more particularly with reference to the straight cyanide process; that is, as originally devised. This process has survived nearly all attempts to replace it with something else, and in principle has undergone no changes. Many other so-called methods, which were only modifications of this well known process, have been launched, tried and have disappeared. They

differed from the original only in one thing, perhaps; as, for example, in the manner in which precipitation was effected, the zinc box extractor being replaced by some other means of precipitation; but it is noteworthy that the original process is used almost exclusively throughout the world, nor has its position ever been seriously threatened.

Bromo cyanidation has met with considerable success, but its application is restricted rather to certain sulphotelluride ores, and then its use would depend largely upon a comparison of cost of treatment by this method and the old method of roasting followed by plain cyanidation. Its success, however, has been remarkable in Western Australia where raw ores are successfully Bromo cyanided. Its use involves fine grinding, the cost of which, plus the cost of Bromo salts and royalties to the patentees, is to be considered.

Precipitation by means of zinc shavings has a fixed place in cyanidation, and no doubt gives greater general satisfaction than could be obtained through any other method proposed, such as precipitation on charcoal, by means of zinc fume, on lead in the electrolytic method, etc. There are instances where special conditions have favored precipitation by other means than with zinc shavings, but the successful issues have been rare.

VARIED METHODS OF PREPARING THE ORE FOR TREATMENT.

The preparation of the ore for cyanidation is accomplished in as many different ways as there are machines used for disintegrating, and the particular class of machinery best suited for any ore will depend upon the physical and mineralogical composition of the ore proposed for treament.

Preliminary breaking of the ore in crushers or breakers is common to nearly every method of ore reduction, while grizzley bars find valuable use in relieving the crusher of unnecessary work.

After preliminary breaking, one ore may require wet crushing in the stamp battery, another a system of gradual or progressive crushing, by means of crushing rolls, either wet or dry, while certain ores must be crushed in the dry state and then roasted to prepare them for successful cyanide treatment. The degree of fineness to which an ore is to be crushed is a question requiring the most careful consideration and when once determined the method by which disintegration is to be effected is selected; one ore will be found to yield the maximum amount of gold and silver in the shortest time at the lowest cost when crushed to coarse size, such, for instance, as will pass a three mesh screen—and such ore would possess sufficient porosity to allow the solution of cyanide of potassium to penetrate and reach the gold and silver contained everywhere within the largest piece of ore; another ore might lack porosity entirely and will need grinding to such a degree of fineness as will insure contact of solution with the gold and silver.

The extent to which grinding will be carried is regulated, not so much by the amount of gold and silver that it will be possible to save by additional grinding, as by the net results attained, expressed in terms of costs, i. e., the process as a whole must not only be a metallurgical success but a commercially good enterprise, so that costs of achieving a desired end form a consideration of the greatest importance.

THE FIRST STEP.

The first step, that of preparing the ore for cyanide treatment, is one involving considerations that tax the cyanide chemist, the metallurgist and the manufacturer of milling machinery to the utmost, and it will be seen that if the preparation of the ore is not effected in the proper manner at the least cost, the process as a whole, and especially the chemical treatment of the ore, will not give the most satisfactory results.

ORE CRUSHING BY ROLLS.

In the treatment of certain ores, especially of low grade character, where the cost of special treatment of slimes would militate against a commercial success, the ore will be cyanided by the straight percolation method, the success of which will depend largely upon the absence of interfering slimes.

The production of slimes in crushing must be kept at a minimum; to this end crushing rolls are employed. Progressive or gradual disintegration of the ore in conjunction with efficient screening is the method which produces the least slimes.

Ores are frequently cyanided at 20 or 30 mesh, and in such a case disintegration would be accomplished by preliminary breaking in Gates Gyratory or other crushers, followed by passage of the material through a set of roughing rolls, the product of which would be screened, with the oversize being returned to same set of rolls and the undersize fed to a set of finishing rolls to be still further reduced in size, thus gradually disintegrating the ore from lumps to the required fineness. After each pass through a set of rolls it is desirable to remove by screening the particles which are fine enough, to prevent their further comminution. Sometimes the ore is made to pass through two, three or even four sets of rolls, as conditions demand.

There are many ores which are most successfully cyanided at the coarser meshes, such as two, three or four mesh. An approved method of crushing an ore to these coarse meshes is by preliminary breaking in a Gates Gyratory crusher, followed by secondary crushing in a Gates fine Gyratory crusher, and finishing in one set of rolls, with screening interposed advantageously.

Crushing rolls and the intelligent use of efficient screening devices, such as revolving or vibrating screens, or both, form an important part in the preparation of an ore that should never be underestimated, even by those who favor stamp

battery crushing or other machinery for disintegration. Many ores absolutely demand crushing by rolls and consequently the skilled laboratory investigator will invariably weigh the merits of roll crushing as applied to any ore under examination.

In using rolls either wet or dry crushing may be practiced.

The limit as to fineness in crushing by rolls is usually accepted as 30 mesh in mill practice, with 40 mesh as an exception.

STAMP BATTERY IN CONNECTION WITH THE CYANIDE PROCESS.

The stamp battery has proved a great success in crushing ore for cyanide treatment notwithstanding the fact that it was formerly considered that successful cyanidation depended upon dry crushing. Wet crushing in this way has become a prominent feature in cyanide operations the world over; while in some cases the ore is crushed dry in the stamp battery most generally the work is done in the wet method.

Crushing in dilute cyanide solution is practiced considerably and is claimed to be a favorable factor in treatment, reducing time required and tending to increase the saving.

Where amalgamation is practiced in combination with cyanidation, the stamp battery is ideal for crushing, and with the progress made in the treatment of slimes, the production of the latter is not so much considered a menace to cyanide treatment. Amalgamation is responsible for a goodly share of the combined saving, and this feature is not to be ignored, especially when it is considered that the results obtained from the single operation of cyaniding refractory ores, raw, might not always be sufficient to justify metallurgical treatment.

THE USE OF HUNTINGTON MILLS.

The Huntington Mill is particularly well adapted for crushing for cyanide treatment, contributes to low working costs and satisfactory savings. It is used extensively for regrinding work, and in addition is very suitable for reducing the product of rolls to size required for leaching treatment. Various sizes of screens may be used, depending upon conditions to be met, ranging from comparatively coarse to very fine. Elsewhere in this bulletin will be found further remarks concerning the Huntington Mill, and the reader is referred to same as well as to our special catalogue on the subject.

CHILIAN MILLS.

For high efficiency and economy of operating the Chilian mill has earned the praise of practical mining men.

In cyanide practice this type of mill is sometimes used for reducing ores to 20, 30 or 40 mesh sizes. The mill is suitable for even much finer comminution, being employed frequently in the production of material all of which will pass a screen of 100 meshes per linear inch.

It is claimed for it, that the product of a Chilian mill contains less metal, abraded from the grinding surfaces of the machine, than is the case with any other type of mill, a consideration of importance, more especially when certain chemical processes are used.

FINE GRINDING.

In the early life of the cyanide process the presence of finely comminuted ore in the leaching vat gave rise to all the difficulties characterizing unleachable ores and the inability to cope successfully with those difficulties at the time, made it imperative that the proportion of fines and slimes approach the minimum possible with any system of crushing, but with the development of the process, and the discovery of successful methods of treating slimes, the same fear of the production of slimes no longer occurs. The fact is the metallurgist now is often confronted with the problem of installing machinery that will accomplish one of the very things he formerly had to avoid—fine grinding.

TUBE AND BALL MILLS.

There are a number of different machines used for fine grinding ore, among them being Tube and Ball Mills, both of which have gained prominence in connection with cyanidation.

In West Australia, in the treatment of raw ores, the method comprehends, in many mills, preliminary breaking in Gates Gyratory crushers, followed by the stamp battery, with subsequent amalgamation and concentration, the tailings of the concentrators being separated into three classes, namely: sands for treatment in leaching vats, slimes for treatment in agitators, and comparatively coarse material which is reground in Tube mills, so that all would pass a screen having 100 holes per linear inch or even more, the product approaching slimes and being cyanided with the other slimes previously separated for treatment, in agitators. For this fine grinding, tube mills have given eminent satisfaction.

Another method which is used involves preliminary crushing in Gates Gyratory breakers, the product of which is fed to Ball Mills, working dry and arranged to reduce the material to a state of fines, all of which will pass a 20 mesh screen. The product of the Ball Mill in this case is roasted and subjected to cyanide and other treatment. There are other mills used in the same field, for producing fine material, but so far none of them have reached the same high state of efficiency as the Tube and Ball Mills.

Elsewhere in this publication will be found illustrated and briefly described the tube and ball mills of our manufacture, and for detailed information, the reader is referred to our catalogues and bulletins which treat more fully of these mills.

ROASTING ORES FOR CYANIDATION.

Roasting for cyanidation is a question requiring the consideration of practical experienced cyanide experts familiar with every detail of the art, and it may be recorded that no branch of metallurgy is so exacting, so far as roasting is concerned, as cyanidation.

Cyanide treatment demands that the roast shall convert the ore into such a state as will aid cyanidation, and in nowise hinder it. If the roasting has not been properly done, certain sulphates of base metals present may remain in the roasted product to destroy cyanide of potassium to such an extent as to not only interfere materially with the dissolving of gold and silver but actually defeat the commercial end sought, by reason of the cost of cyanide consumed.

The roast most generally given an ore preliminary to cyanide treatment is an oxidizing one, while in the case of treating a purely argentiferous ore a chloridizing roast is giving great promise as a valuable aid to cyanidation.

Roasting affects the physical condition of an ore, promoting porosity, as well as changing its chemical constitution; the resultant product should be such as to make a satisfactory saving of gold and silver by cyanide of potassium a matter of easy attainment. Roasting, then, necessarily done at a cost not prohibitive, has to be effected in a furnace built to meet the needs of a cyanide roast, which means, among other things, that the heat must be applied to the ore in its passage through the furnace with particular regard to the chemistry of the operation.

An oxidizing roast must be carried to the point of "dead" roasting, i. e., to as complete an elimination of sulphur as is possible. Most of the oxidation will occur at a dull red heat, and at this stage more or less sulphates of the base metals will form, to decompose which the temperature must be raised to a bright red heat. This higher temperature must be imparted to the ore at the critical moment, and at a point in the furnace removed from that where the oxidizing temperature prevails. This higher heat should be of sufficient intensity only for the decomposition of the sulphates, a still greater heat being liable to cause fusion, in the presence of certain metals.

It might be far better to forego roasting entirely and to treat the ore in a raw or unroasted state than to subject an imperfectly roasted ore to cyanide treatment with consequent prejudicial effect on extraction and prohibitive cost for cyanide of potassium.

BEGINNING THE PROCESS OF CYANIDING.

After the ore is crushed for treatment the important operation of "cyaniding" begins, and if the ore requires no classification, and has been crushed dry, it is at once charged into leaching vats for cyanide treatment. Some ores, however, are so physically made up that when charged into a leaching vat the cyanide solution will not percolate with sufficient rapidity through them to give a profitable saving,

owing to the great length of time required for their treatment and in certain cases the passage of the solution is nil; in the earlier life of the process some of these ores were abandoned as unsuitable for treatment and then it was the Cyanogen was said to have been dethroned. The cyanide process was condemned in so many instances, through reasons of this and other kinds, that a rapidly growing faith received considerable shaking, but the believers remained true and the real believers were men of great metallurgical attainment, who, supported by the efforts of the machinery manufacturer, brushed aside the difficulty referred to, as well as many others of greater and lesser importance. As a result, it is now known that if an ore on account of its slimy nature defies treatment by the percolation method, other means are available for its successful cyanidation.

SLIMES NO LONGER FEARED.

In some sections of the world, with many ores, fineness of the crushed product is desired rather than avoided and the suggestion that certain classes of ore be finely ground—reduced to a state of division closely approaching slime—has been received with considerable favor by experts whose efforts have been directed toward the development of cyanide treatment of unroasted ores. However, ores containing both coarse and the regular gradations in sizes down to slimes present difficulties in treatment which render their classification necessary; the ore is separated into "sands" and slimes, prior to cyanidation, the former receiving treatment in the leaching vats and the latter being subjected to agitation with cyanide solution in agitating tanks, followed by separation of the precious metal-bearing solution from the slimes, usually by either the decantation or filter press methods.

SEPARATION OF SANDS AND SLIMES.

Where the slimes exist in prejudicial proportion, as regards percolation, and agitation must form a part of the operations and classification into "sands" and slimes is necessary, the work must be blended in with the task of eliminating the excess water and the charging of the leaching vats, so that the correct proportion of slimes will be removed from the "sands" for agitation treatment and no "sands" will reach the agitators. These, when working properly, achieve their purpose with gold ores usually in the maximum time of sixteen hours, and commonly in less time, so that any coarse ore particle finding its way to the agitators would not yield its gold and silver in the allotted time and thus the saving would be impaired.

The instance is not uncommon where the separation of "sands" and slimes is so faulty as to partially reverse the conditions needed for good extraction—where the leaching vat receives an undue proportion of slimes, and "sands" are diverted to the slimes plant, with the result that the respective steps of cyanidation suffer to a degree which clouds the enterprise as a commercial proposition. Such a condition, if the equipment used is what it should be, demands correction at the hands

of a cyanide man whose mastery of the details of cyanidation is complete. Classifiers, V-shaped, conical and other shapes find use in this important work, with, perhaps, the spitzkasten employed most extensively.

METHODS OF CHARGING LEACHING VATS.

The methods used for charging leaching vats may be classified as "direct" and "indirect" filling, and a selection of the kind to be employed will invariably be based upon the nature of the crushed ore, the respective merits of the methods for that particular ore and cost of accomplishment, together with results in the way of recovery obtained.

DIRECT FILLING.

Direct filling involves the use of some sort of pulp distributor or a method of distributing the pulp in such manner as to place the pulp into the leaching vat so that the different sized particles of ore will occupy definitely related positions and thus insure the uniform passage of the cyanide solution through the mass. Imperfect filling leads to the deposition of material some portions of which resist the passage of solution more than others, and the cyanide solution follows the lines of least resistance, with the result that gold and silver is dissolved only from the ore in spots, thus accounting for a low extraction.

Among the appliances used for direct filling in the wet, one of the most successful is that known as the Butters and Mein's Distributor, described elsewhere in this catalogue.

There are other distributors and other methods used for direct filling, many of which are giving satisfaction.

INDIRECT FILLING.

Indirect filling comprehends the separation of a crushed product into sands and slimes and water, the settlement of the sands so separated in boxes or tanks suited for the purpose, from which the material is usually removed by hand to the leaching vat, in which the cyanide treatment is to occur.

Both methods of filling have advantages.

FILLING WHEN DRY CRUSHING IS USED.

Where dry crushing is practiced, the material is charged into leaching vats direct by any of the well known means, such as tramming in ore cars or by conveying belts. In dry filling every precautionary measure should be taken to avoid packing of the ore in the vat, which has the effect of retarding percolation, and leads to an uneven passage of solution through the body of the ore.

LEACHING PROCESS.

In the simple application of the cyanide process, in the case of dry crushing, the raw or roasted ore is charged into leaching vats for treatment with cyanide solution. Either at some point in the crushing operation or when the vats are being filled lime is added for the purpose of neutralizing the acidity of the ore. Sometimes an alkaline wash is given the ore in the vat previous to introduction of cyanide solution.

Cyanide solution is introduced into vat either by upward percolation from below the filter bed or introduced on the top of the ore, or use is made of both methods. Care is exercised that the ore will take the solution without channeling.

After thorough saturation of dry ore, the solution being allowed to stand about 2 inches above the top of the carefully leveled ore, percolation may be commenced at once, if maceration is not desirable. The working solution is turned on to the top of the ore and the solution filtering downward through the mass is allowed to drain to gold tanks, whence it is eventually conducted to extractors for precipitation of the gold and silver contents.

Various strengths of solution are employed to dissolve the gold and silver, depending upon the ore, while the time of treatment also varies. The quantity of cyanide solution applied is also variable.

Finally wash water is used to displace as far as practicable the cyanide solution remaining with the mass of ore. Necessarily, this wash must be restricted and is usually such as will preserve the "balance" of solution in the mill.

Solutions are manipulated in accordance with the best judgment of the man in charge and in the way best calculated to yield the highest extraction.

In the treatment of "sands," the only difference in the method just described would be due to filling, the ore being already wet, and percolation with cyanide solution is commenced as soon as the vat is filled and partially drained of the crushing water or solution.

DOUBLE TREATMENT.

Leaching vats are arranged in many plants so that a charge of ore which has been subjected to leaching treatment for a number of days in one vat, may be drained of its solution and transferred to another vat for further cyanide treatment. This is known as double treatment, and its use with many ores undoubtedly results in higher extractions.

The transfer from one vat to another affords aeration of the material, besides rearranging all the particles of ore. The benefit is apparent after a few days' treatment in the second vat.

The vats in which first treatment is accorded are generally superimposed above the second treatment vats. In some plants they are arranged on the same level

and the transfer of ore from one vat to another effected by means of mechanical excavators and conveying belts.

THE TREATMENT OF SLIMES.

In the treatment of slimes, after the slimes have been separated from the sands, they are thickened in "V" shaped boxes or conical bottom tanks, when they are conducted to agitators, there receiving a charge of lime or caustic soda to neutralize acidity and subjected to agitation with cyanide solution.

AGITATION.

Agitation may be accomplished in several ways but the most prominent methods in use employ mechanical stirrers or centrifugal pumps, or a combination of both. The centrifugal pump is a later adaptation of the agitation process but has proven well suited to the purpose.

When mechanical stirrers are used, the slimes are agitated by means of revolving arms fitted in tanks, for a suitable period, when the pulp is allowed to drain from the agitator into a well from which it is pumped direct to filter presses in which the gold and silver bearing solution is separated, after which the solution drawn away from the presses may be clarified and then conducted to gold storage tanks, whence it is allowed to flow to precipitating boxes.

MONTEJUSES.

Montejuses are sometimes used for charging filter presses in place of pumps and by many are considered the more satisfactory. The Montejuses make use of air pressure for raising and forcing the pulp into the presses.

AGITATION BY MEANS OF CENTRIFUGAL PUMPS.

If agitation is effected with a centrifugal pump, the agitation vat is usually constructed with a conical bottom with suitable slope. An orifice is situated near the bottom through which the material may be finally discharged. A centrifugal pump is so connected with the tank that the pulp may be drawn from most any position inside of the tank, passed through the pump and elevated to the height of the tank, returning to the same tank at a point close to the bottom, thus establishing a circulation which promotes continued disturbance of every particle of slime and cyanide solution in the charge undergoing treatment, ensuring dissolving of gold and silver in the shortest time possible. After agitation is complete the contents of the agitator are transferred to a similar vat used for decantation.

DECANTATION.

In the decantation tank the solid matter is allowed to settle and the solution is decanted, usually by means of a decanting pipe or hose attached to a float, and conducted thence to the extractor house for precipitation. The decantation vat is

then recharged with precipitated cyanide solution or water and the centrifugal pump is put to work and agitation commenced for the purpose of intimately mixing the slimes with the new charge of cyanide solution or water, when settlement is again allowed to occur. This operation is repeated until a satisfactory separation of the gold and silver bearing solution and the slimes has been effected when the residue is discharged and runs to waste.

FILTER PRESSING—ITS SUCCESS IN WEST AUSTRALIA.

The filter press is an adaption in cyanide work, having been successfully used in other industries. After a series of repeated failures, in almost all of which its attempted use was abandoned, West Australian interests renewed the work of experimenting with, finally, most gratifying results. The ores of that section when treated raw require fine grinding to the point of sliming, and the successful work of the filter press makes it possible to practice such grinding.

ITS ADAPTABILITY TO OTHER FIELDS.

The filter press is not restricted to use with sulpho-telluride ores nor confined in employment to West Australia. There are many ores in various sections of the United States and other countries not now being treated owing to certain physical properties which interfere. Many of these could be made to yield their gold and silver contents by cyanide treatment embracing filter pressing.

OTHER METHODS OF TREATING SLIMES.

The filter press as generally known is intermittent in its operation. The cost of installation and expense of operating sometimes prohibit its use.

Continuous filter pressing in self-discharging filter presses, in combination with replacement leaching therein, is receiving the attention of eminent men in the metallurgical profession. It is claimed that such a method offers all the advantages and scope afforded by leaching tank work besides giving the same economy and higher extraction.

Other methods have been proposed for slime treatment, and tried. One worthy of note made use of a basket of canvas-covered filter frames, which was mechanically immersed in a tank containing the slimes which had been agitated with cyanide solution. Filtration was caused by means of a vacuum. The suction caused the slimes to collect on the filter surfaces in layers or cakes. The apparatus with adhering slimes was subsequently transferred to another tank for washing of the slimes.

Efficiency and economy were claimed for the method. However, the suggestion that the method be improved to make of it a continuous process possessed merit and it is understood that progress is being made in this direction.

Methods other than, as well as, those described herein lend justification for the hope that slimes may eventually be treated less laboriously, at lower working costs and with higher extraction.

PRECIPITATION OF GOLD AND SILVER.

The chemistry of precipitation is very complex, and the chemical reactions that occur in the zinc box are so varied and some of them so obscure and yet so vital to the undertaking that the cyanide chemist is frequently called upon for the exercise of the highest skill.

The manufacturer views the problem more particularly from a mechanical standpoint, thus aiding the chemist through the production of zinc boxes best suited to meet the requirements of the process, minimizing some of the difficulties encountered in precipitation, as well as facilitating easy dressing of boxes with zinc shavings and making the periodical cleanup a matter of great simplicity.

RECOVERY OF PRECIPITATED GOLD AND SILVER.

Various methods of cleaning up zinc extractors and reducing the precipitates to bullion form are in use, and the practice employed at any plant always conforms with the particular ideas held by the man in charge, although some steps in the operation are common to all methods.

Periodically, the precipitates, with more or less zinc are removed from the zinc extractors for treatment, preparatory to final reduction by fire. Usually dilute sulphuric acid is used to dissolve the zinc with which the gold and silver is associated, after which the concentrated mass is conducted to a small filter press for thorough washing to remove as far as practicable the acid and soluble sulphates. Compressed air is then used to dry the precipitates.

The dried precipitates are roasted in a muffle furnace to eliminate remaining sulphates of the base metals, more especially zinc sulphates.

The roasted precipitates are then fluxed, economically, with borax, silica and bicarbonate of soda, and charged into crucibles for fire reduction. In the resulting fusion a slag should be produced that will give a good separation of the bullion.

The recovered bullion will be contaminated with more or less zinc and other base metals, but is usually fine enough to be satisfactory. Refining of the bullion bars on the premises beyond the purification that would result from remelting once or twice, is a question that would depend upon the conditions imposed by the mints and penalties exacted for impurities in the marketed bullion bars.

There are instances where the precipitates are sold direct, without any attempt at reduction in the cyanide plant, to reputable custom refineries. In some of these instances the cyanide managements prefer to forego the operation of producing bullion, often for the reason of difficulties encountered in refining.

Generally, however, the gold and silver extracted in cyanide treatment is reduced to bullion form upon the premises.

IMPORTANCE OF FIRST-CLASS CLEAN-UP EQUIPMENT.

The appliances used in the clean-up and bullion department are of such importance that a high grade quality of equipment is excellent insurance against loss of gold and silver.

The slag and old crucibles can be worked over economically on the premises and much of the gold and silver bullion existing therewith recovered; with this end in view, the slag and other material may be crushed and screened and that which passes through the screen treated upon a concentrating table for the recovery of the bullion. The tailings from this operation are generally sold to the smelter.

DISPOSITION OF TAILINGS.

Tailings may be removed from leaching vats by sluicing and this method is practiced invariably when the tailings are to be treated upon concentrating tables for the recovery of some of the precious values that have not been saved by cyanide—such as sulphurets, etc. Sluicing will always find favor where water is abundant, and there is no objection to the tailings leaving the mill site, and where such objection does exist, in some instances, the tailings are impounded within a dam, this rendering sluicing possible.

Conditions for impounding tailings are not always favorable, water for sluicing not always available and in such cases the tailings may be removed from the leaching vats by shoveling by hand or with the use of mechanical excavators. The tailings are either removed in cars or by conveying belts. In a flat topography the conveying belt has the additional advantage of enabling the stacking of the tailings in heaps of considerable height a task that is performed economically as well.

The residues of filter presses may be handled in any of the ways described.

It is common practice in some mining districts to utilize the cyanide tailings for "back filling" of stopes in the mines, thus turning the refuse material to valuable account, at the same time overcoming the difficulties due to limited storage space on the surface of the property.

COMBINED TREATMENT METHODS.

The cyanide process is frequently used in combination with amalgamation and concentration. The order in which the various processes will be arranged for the whole treatment will depend largely upon the character of the ore.

In some mining districts the ore is first amalgamated and then passed over concentrating tables to remove the suphurets as concentrates for separate treatment, or shipment to the market for sale, while the tailings of the concentrators are subjected to cyanide treatment.

Another method provides for amalgamation, followed by cyanidation, to be finally followed by concentration of the cyanide tailings.

Amalgamation and cyanidation form a combination most suitable and economical for certain ores, while in the case of dry crushing, with some ores, cyanidation and concentration are used to advantage.

Combined treatment by Lixiviation with hyposluphite to recover the silver and cyanidation to extract the gold contents of ores amenable to such treatment has very strong advocates in the metallurgical field.

Wherever metallurgical conditions demand and net results justify combined treatment will continue to find employment.

PART II.

With this introduction, we present on the following pages
a description of our

Crushing Machinery and Equipment for the Cyanide Process.

SELECTION OF EQUIPMENT.

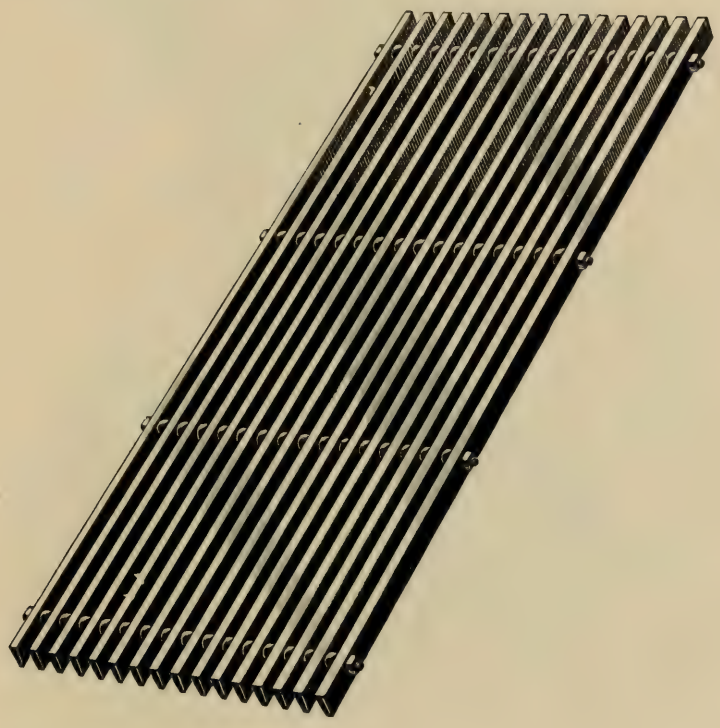
As manufacturers of cyanide equipment, we feel it due to the practicing cyanide chemists and metallurgical engineers to leave to them the matter of investigating ores proposed for cyanidation, and after this has been accomplished our usefulness to the promotors of cyanide enterprises begins.

Whether used singly or in combination with any other process the machinery to be employed should be selected by those whose long experience qualifies them for the important undertaking.

Our many years of success in such matters particularly renders us capable of planning, devising, designing and building equipment along most improved and approved lines, and it is a tribute to our ability that we are consulted in nearly every case involving installations of the greatest importance and magnitude.

Whatever method of preparing the ore for treatment is proposed, wet or dry, whether it is accomplished by crushers, stamps, rolls, Huntington, Ball or Tube Mills, or any of the other grinding machines; whatever the method of classification, the manner of filling leaching vats, or discharging them, together with the mechanical handling of the ores, before treatment, or of the residues after treatment; in whatever manner the ore is to be cyanided, whether roasted or raw, by straight leaching or agitation or their combination; no matter what treatment is accorded the sands or slimes, with all the variations possible, preceding or following such treatment, whatever the difficulties to be overcome through mechanical means, we, as engineers, backed by years of experience in successfully meeting the demands of the metallurgical industry, in its complex as well as simple phases, are enabled to cope with, and surmount the many problems presenting themselves for solution, and consequently furnish our customers with equipment best adapted for the treatment of their ores.

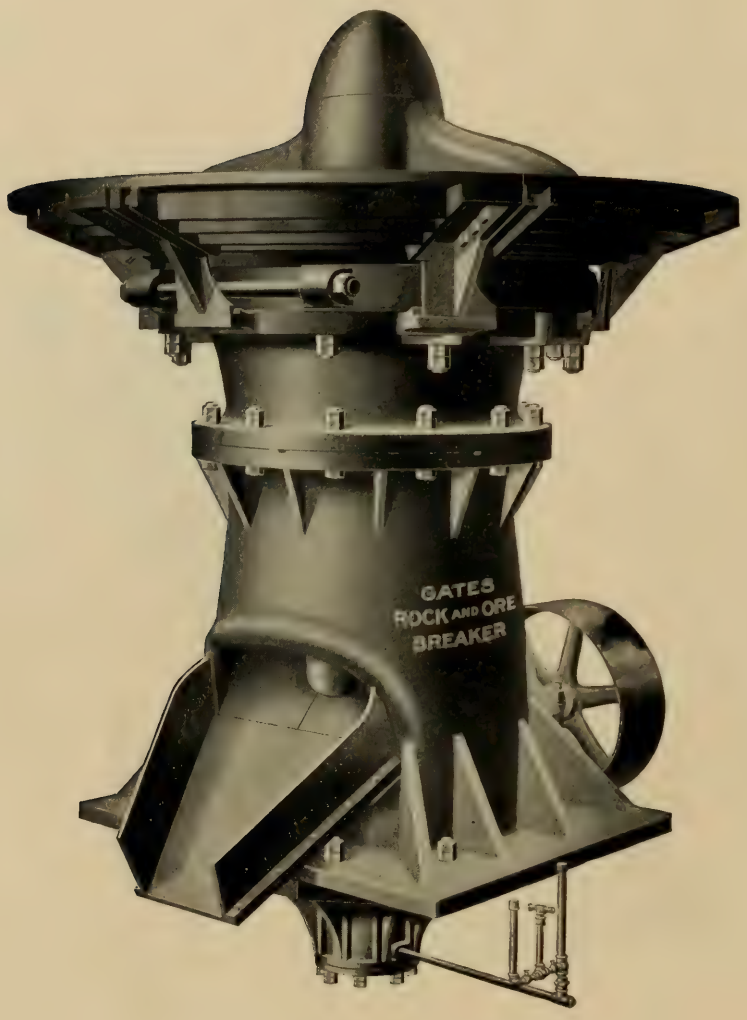
Plate No. 243M



ORE GRIZZLEY.

Grizzleys are usually from three feet to six feet wide, and the length of the bars varies from eight to twelve feet. These are usually set at an angle of 45° to 55°, according to the nature of the ore. We build them at any size required, bars being of taper section.

Plate No. 1440



GATES ROCK AND ORE BREAKER.

We present an illustration of Style "K" Gates Rock and Ore Breaker. The capacity of the breakers is greater or smaller, depending upon the hardness of the ore and the size of product required. If the breaker is to be located at the top of the ore house, the use of this machine will allow of a lighter construction of frame work than would be necessary were a jaw crusher used, as the shaking or jarring common to all jaw crushers is eliminated in the Gyratory Breaker.

The capacity of stamp mills and other fine crushing devices is largely affected by the size of the ore fed to them. The ore breaker ought to do all the work possible, as it is economy to push that machine to its limit and thus relieve the mill. The published reports of the leading mining companies in South Africa testify to

the great increase in the stamp mill outputs after the introduction of the Gates Breakers.

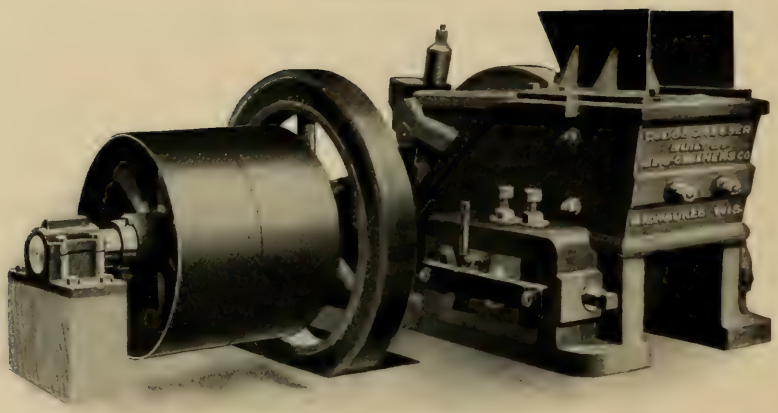
In reducing rock or ore to a fine product, it is essential that the material be reasonably dry. Wet and sticky ores will pack in fine breaking. While experience has demonstrated that our Breaker is better calculated to handle wet ores than any other machine, we will not guarantee what must be manifestly impossible to any reasonable person.

Plate No. 2066

THE BLAKE ORE CRUSHER.

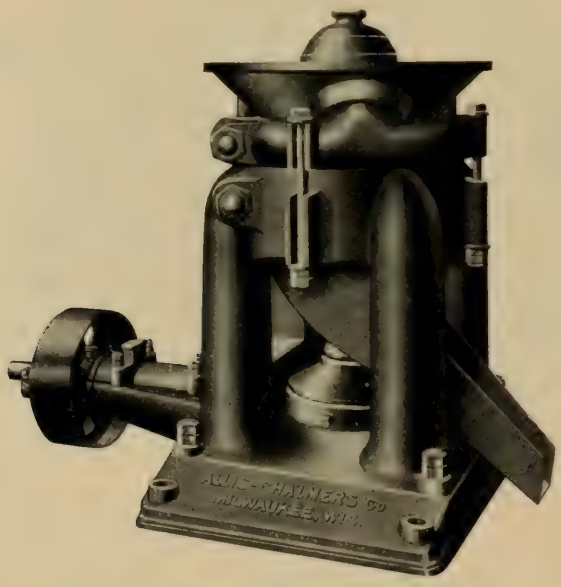
The Blake Crusher (plate 2066) has long been a standard machine for reducing rock preparatory to finer crushing or pulverizing by stamps, rolls or Huntington mills. It is durable and simple to operate, being now so well known as to require little explanation.

Plate No. 2070



The Dodge Crusher (plate 2070) has been long and favorably known for its simplicity of construction, ease and range of adjustment, accessibility of all working parts, together with the uniformity of its product. In comparison with the "Blake" crusher the "Dodge" can be set to crush finer though the "Blake" has the greater capacity.

Plate No. 397G

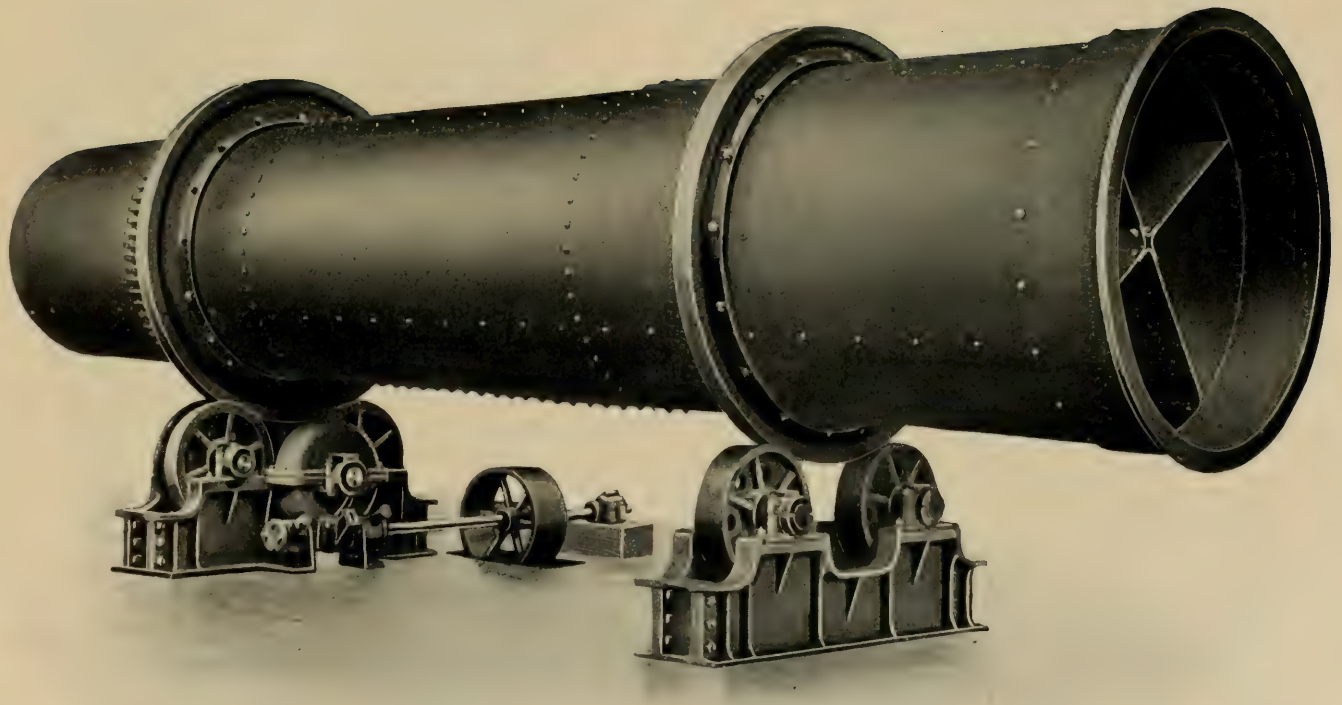


OUR NEW "F" BREAKER.

Patented.

Style "F" is our latest production in the line of a small breaker and a machine that finds favor as most suitable for breaking slag and waste products of the bullion room preparatory to the recovery of gold and silver values, existing as shot, etc. This machine will receive ore the size of a hen's egg and break down to 3/8 inch—capacity about 1,000 pounds per hour. The product, after being reduced in the "F" Breaker to 3/8 inch, is ground in our Style "B" Sample Grinder.

Plate No. 1185



IMPROVED REVOLVING DRYER.
(Steel Construction.)

REVOLVING DRYERS.

Plate 1185, on page 21, shows a type of revolving dryer we manufacture for use in crushing plants.

When it is required to crush an ore dry to any of the finer meshes, it is quite essential for crushing and screening purposes that the ore be free from moisture and in an effort to attain this end, the ore is exposed to the danger of overheating. An incipient roast results from this overheating with inevitable production of soluble sulphates of the base metals, which not only interfere with a satisfactory saving but destroy cyanide of potassium as well. Our revolving dryers are designed for the purpose of effecting thorough elimination of moisture without in any wise altering the chemical constitution of the ore.

ELEVATORS AND CONVEYORS.

We have made a special study of elevators and conveyors and aim to build these accessories in accordance with the demands imposed by the mechanical and metallurgical treatment of ores.

Our continuous bucket belt elevators are famous and have stood the test of years of use in crushing plants, giving the greatest satisfaction.

We supply elevators of any style for mill work, furnishing them with any of the different kinds of buckets, as desired.

Our conveying appliances have rendered signal service in the metallurgical industry and are designed to meet almost any requirement.

We are prepared to supply conveyors of the belt, flight or screw types, for handling ore, dry, wet or hot as the case may require.

TROMMEL OR CYLINDRICAL REVOLVING SCREEN.

Plate No. 1407

Plate 1407 shows a type of revolving screen largely used in the cyanide process. The illustration obviates the necessity of descriptive matter, as all the good features of this screen are easily discerned.

Plate No. 3202

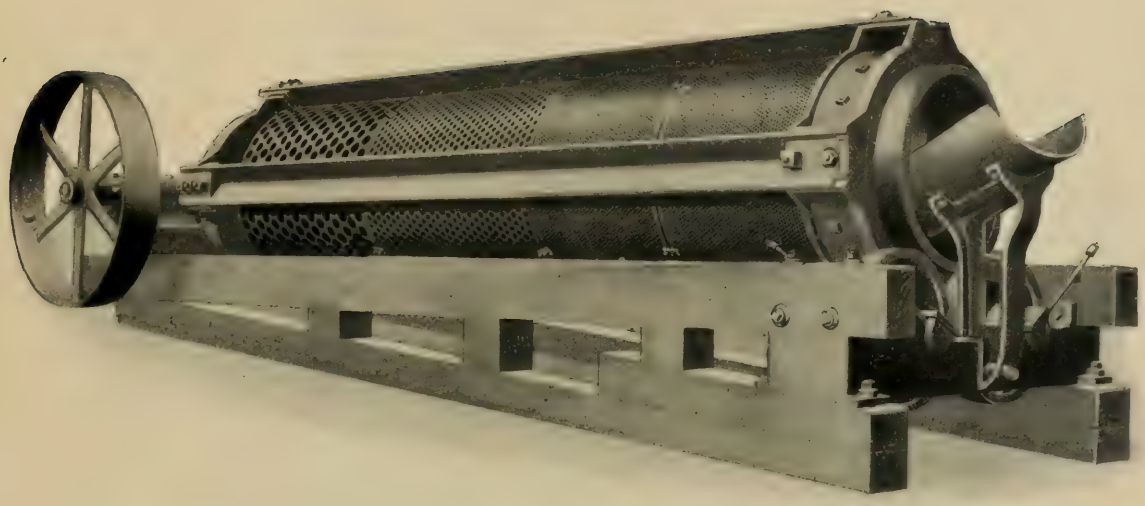
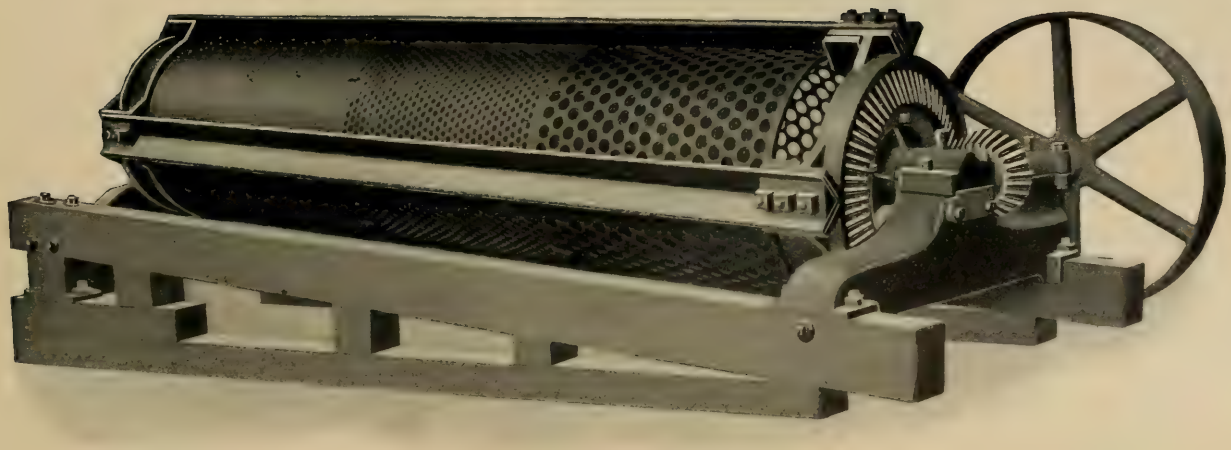


Plate No. 1369



GATES PATENT "IRON FRAME" REVOLVING SCREEN.

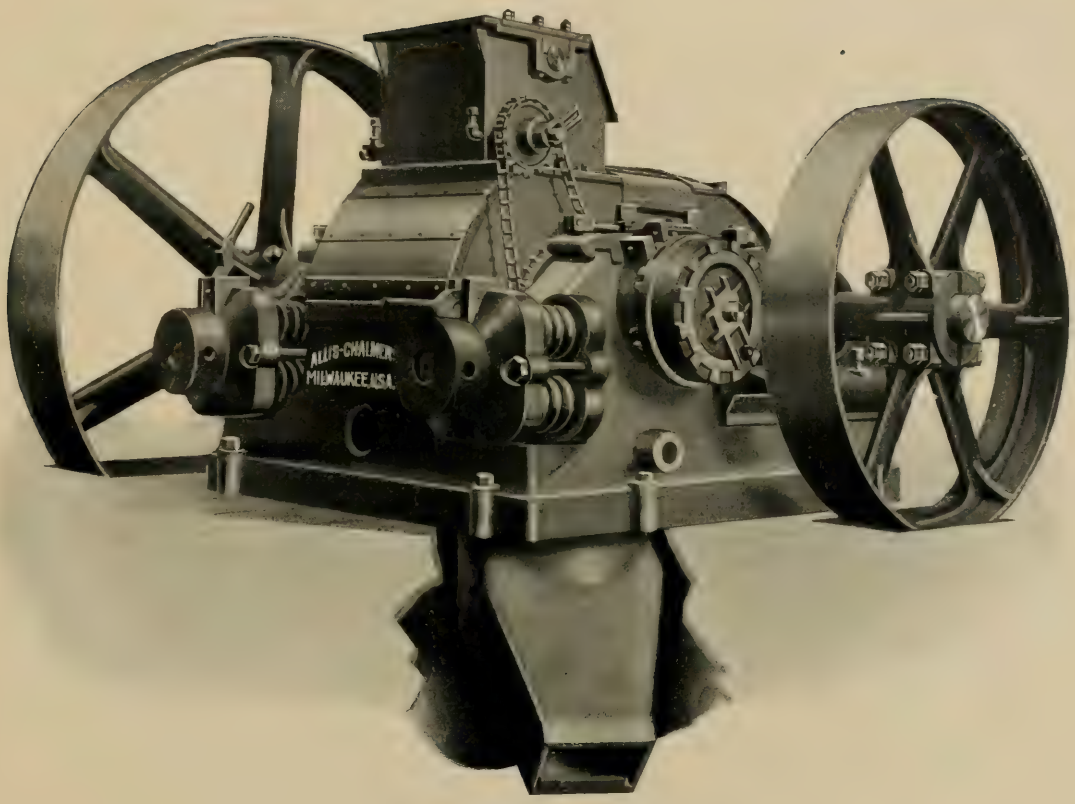
Plates 1369 and 3202 show our (Gates) iron frame revolving screen mounted upon timber and operated by driving gear. This screen is very serviceable, especially in cyanide plants where coarse crushing is practiced.

Plate No. 777G

OCTAGON SCREEN WITH HOUSING.

Plate 777G illustrates our Octagonal revolving trommel complete with sheet iron housing, as used in wet crushing. This style of trommel permits of easy changing and renewing of screen wire.

1389



STYLE "A" CRUSHING ROLL.

Plate No. 1389 shows our style "A" Crushing Roll. These rolls are of extra heavy proportion. The base frames are of rigid design made in a single piece, the support for the bearings of the stationary rolls being cast as part of this same piece. The frames are provided with planed slides for the pedestals of the movable rolls, these slides being fitted with very wide semi-steel wearing plates, facilitating replaces and obviating the wear of the actual roll frame by the motion of the sliding pedestals. A single heavy forged steel tension rod passes through each sliding pedestal and through recesses bored in the frame below the stationary bearing.

Nests of heavy helical steel springs are used to maintain the requisite amount of pressure between the rolls, the arrangement being such that the springs may be set up to the proper compression to bring the sliding pedestals hard against a series of removable plates which determine the opening between the rolls. Special bolts are used in the collars outside the nests of springs so that when it is desired to remove a roll shaft the springs can be compressed by the use of these bolts and the adjustment of the springs may be maintained while the roll shaft is being removed and replaced.

The movable bearings are so constructed and so set in their supporting casting that they may freely swivel and permit the roll shaft to accommodate itself to the passage of a hard substance through one edge of the rolls without subjecting the machine to a one-sided strain which might result in a serious injury.

The movable roll shaft is furthermore provided with an improved side adjustment which is fully described later on. All the bearings are lined with best babbitt metal and provided with efficient dust covers. The roll shafts are of the best forged steel, carefully turned, and the cast iron roll centers are forced on to them by hydraulic pressure. The roll shells, unless specifically ordered to the contrary, are made of the best quality of rolled steel, bored with a double taper to fit the roll centers and the centers drawn together by means of heavy bolts.

Each roll is provided with one large pulley on the stationary roll shaft and one small pulley on the movable roll shaft. The pulleys are made with clamp hubs, reducing the danger from casting strains, rendering them easily placed and replaced on the shafts and permitting a very rigid attachment to the same.

The rolls may be furnished either with a plain hopper or with our automatic feeder. The lower part of the roll frame is hopper shaped and has an inclined spout attached to it in such a way that it may be rotated so as to point in any desired direction. This spout has on its lower inside face a hard iron liner easily replaced. This liner is placed in such a position that all material falling from the rolls will strike upon it and thus any wear on the parts other than this replaceable liner is avoided.

All nuts on the rolls are either the special clamp type or are provided with some suitable arrangement so that they cannot become loosened by the jar caused by the running of the rolls.

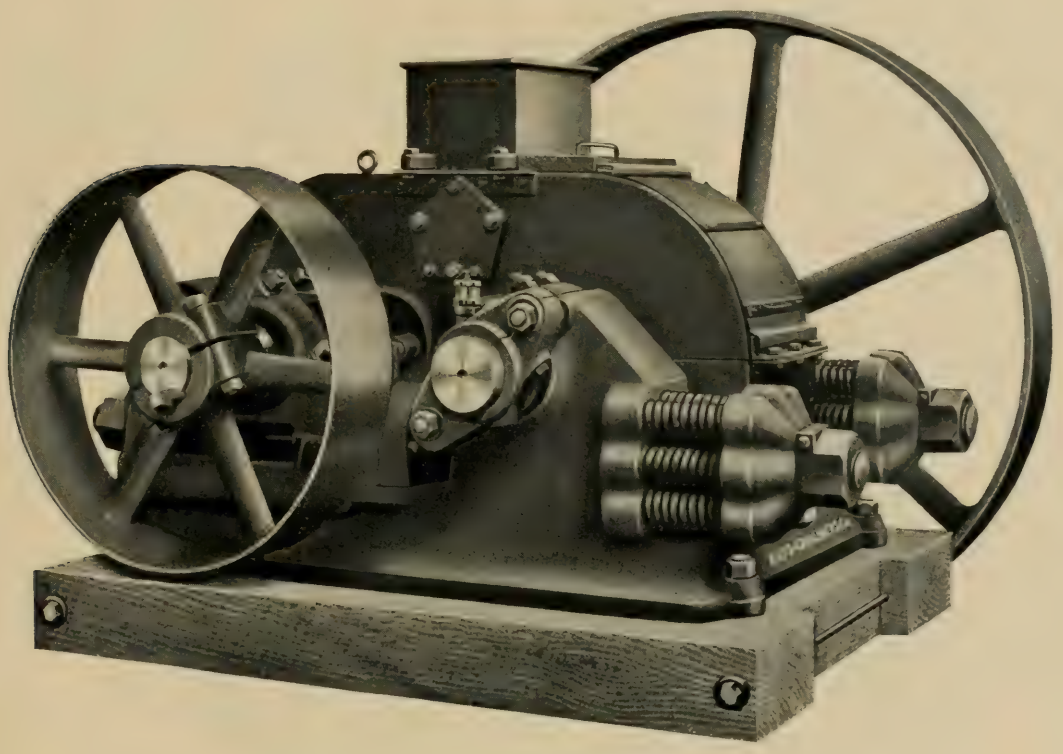
SIZES OF STYLE "A" ROLLS.

Size of Rolls inches Dia. x Face	Size of Driving Pulleys inches Each Roll	Revolutions per Minute
26 x 15	One 72 x 12 and One 48 x 8	75 to 125
36 x 15	One 96 x 15 and One 72 x 8	40 to 100

STYLE "B" CRUSHING ROLLS.

Style "B" Crushing Rolls shown by plate No. 4338 are of heavy proportions. The base frames, in a single piece, are of rigid design—the bearings of the stationary rolls being cast as part of frame. The frames are provided with planed slides for the bearing supports of the movable rolls, these slides being fitted with removable forged steel wearing plates, obviating wear of actual roll frame by motion of sliding

Plate No. 4338



STYLE "B" CRUSHING ROLLS.

boxes. A single heavy forged steel tension rod with a collar solidly forged upon it passes through each sliding box, and through recesses cast in the frame below the stationary bearing.

Heavy helical steel springs are used to maintain pressure between the rolls. Removable distance pieces are interposed between the facings on the movable bearings and the collars of the tension rods, making possible any desired amount of compression without danger of rolls actually coming in contact.

The movable bearings are so constructed and so set in their supporting castings that they may freely swivel and permit the roll shaft to accommodate itself to the passage (of a hard substance) through one edge of the rolls without subjecting the machine to a one-sided strain which might result in serious injury.

The movable roll shaft is furthermore provided with an improved side adjustment which can be set while the rolls are in operation, and which will not loosen nor alter its position in consequence of the jar of the machine. All the bearings are lined with the best babbitt metal, and are fitted with efficient dust covers on their inside ends. The roll shafts are of best forged steel, carefully turned, and the cast iron roll centers are forced onto them by hydraulic pressure. The roll shells, unless specifically ordered to the contrary, are made of the best quality of rolled steel, bored out tapering to fit the roll centers and held in place upon these centers by means of heavy draw bolts.

Each roll is provided with one large pulley on the stationary roll shaft, and one small pulley on the movable roll shaft, the diameters of these pulleys being indicated in appended list. The pulleys are made with clamp hubs, reducing the danger from casting strains, and permitting a very rigid attachment to the shaft.

The rolls may be furnished either with a plain hopper having distributing plates and inside wearing plates, or preferably, with a dust-tight sheet steel housing carrying a similar hopper. The side wearing plates within the hopper are of extra hard white iron, and are fitted with a positive adjustment so that they may be set close to, or at any desired distance from, the edges of the rolls, as may best suit the size of material being fed in, and their positions maintained as wear takes place.

The larger nuts on the tension rods, as well as the nuts on the bearing bolts, are of special clamp type, and will not be loosened by the jar of the rolls.

We build our style "B" Crushing Rolls in four standard sizes, as shown in following table:

STANDARD SIZES OF STYLE "B" ROLLS.

Size of Rolls inches Dia. x Face	Size of Driving Pulleys inches Each Roll	Revolutions per Minute
24 x 8	One 60 x 8 and One 26 x 8	100 to 160
24 x 14	One 60 x 8 and One 26 x 8	100 to 160
30 x 10	One 78 x 10 and One 34 x 10	75 to 130
36 x 12	One 84 x 10 and One 42 x 10	50 to 100

We also build seven special sizes of style "B" rolls, for full information regarding which the reader is referred to other publications of our issue.

STYLE "C" ROLLS.

For less exacting service we manufacture, in three standard sizes, crushing rolls designated as style "C" Rolls. Special sizes of these rolls may also be had.

While these rolls have given great satisfaction for years in the class of work for which they are adapted, they do not embody all the improvements to be found in the higher grade rolls of our production. They are more fully treated of in other literature to be had upon request.

THE USE OF OUR ROLLS IN THE MINING INDUSTRY.

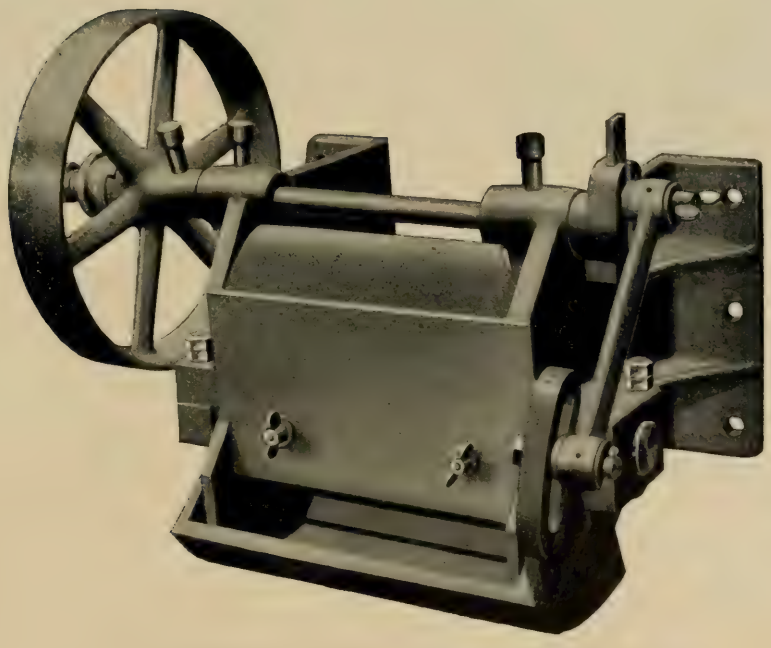
The rolls of our manufacture are used in nearly every mining district in the world. In the United States, Mexico, South Africa and many other countries they are regarded almost unanimously as the best, from every standpoint.

Among the prominent plants using our Style "A" Rolls may be mentioned the De La Mar Golden Gate Mill, one of the largest and most important cyanide enterprises in the world.

To enumerate the names of all the users of our various rolls would require more space than the scope of this publication would permit. Be is sufficient to say that quality, life and meritorious performance of rolls of our manufacture have caused their fame to be indelibly recorded in mining and metallurgical history.

FEEDERS.

Plate No. 1906

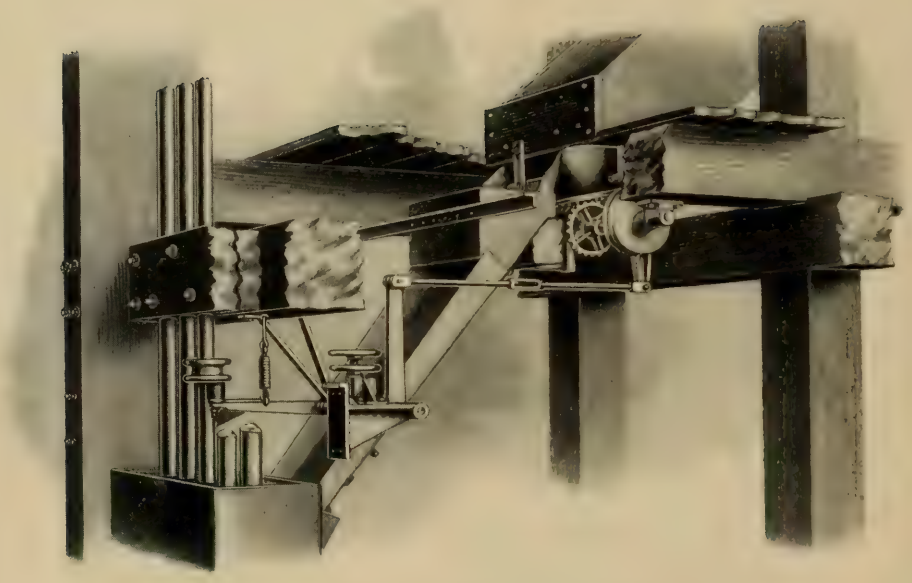


AUTOMATIC BELT DRIVEN FEEDER.

(Known as the Wall Type.)

Plate 1906 shows our wall type feeder operated by belt, a very useful accessory for maintaining proper feed of ore to machinery.

Plate No. 290

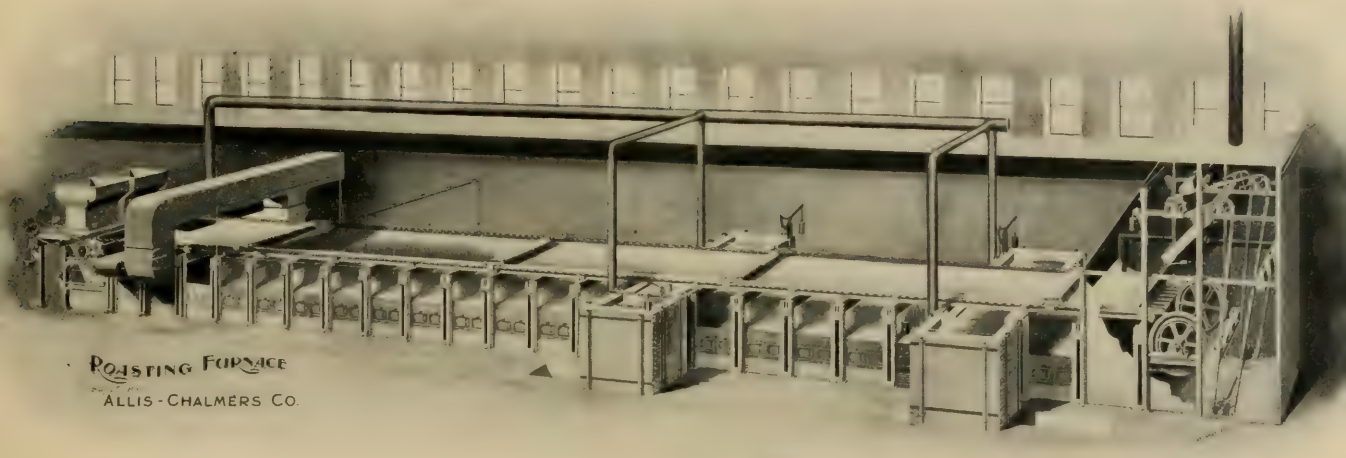


FIXED SUSPENDED AUTOMATIC FEEDER.

Plate 290 shows our tappet driven fixed suspended Challenge Feeder so largely used in connection with stamp batteries and which has such a wide range of usefulness not only throughout metallurgical work, but as well in many other industries where machinery or machines require a positive and steady feed. For other than stamp battery work the feeder is arranged to be operated by a belt.

We manufacture other types, such as the well known Standard and Movable suspended tappet driven Challenge feeders, Tullock tappet and belt driven, movable suspended or otherwise—as well as the Gates "H Style" and Ball Mill feeders—those of our make being of such variety as to be of service in connection with any sort of machines or machinery.

Plate No. 3590



ALLIS-CHALMERS ROASTING FURNACE.

The Allis-Chalmers straight line roasting furnace, shown in Plate No. 3590, embodying all of the good features of the Brown, Wethey and Jackling furnaces, is a single hearth reverberatory with an interior slotted wall on each side of the hearth which is covered with a low arch. The general arrangement of this furnace is similar to the older furnaces mentioned above, the machinery for the furnace proper being located at one end, the elevator machinery for handling the calcines and delivering them on the cooling hearth at the other end. External fire boxes located alongside the furnace in the usual manner supply the necessary heat for roasting inert material or the dead roasting of sulphite ores.

In the conduits formed by these slotted and interior walls of the furnace are placed rails upon which run the carriages supporting the stirrer arm which projects through the slots and over the hearth of the furnace. Fastened to this latter portion of the arm are shoes or rakes resembling miniature plow shares, which dip down into and thoroughly stir the ore lying in thin layers on the hearth.

The stirrer carriages, of which there are never less than two, are moved over the hearth in the direction of the elevator and by two chains driven from the feed end by means of gearing and sprockets, adjustable to allow of wear and the extension of the chains. This gearing is provided with an automatic trip which stops the machinery should an accidental obstruction put undue strain upon the chains.

This entirely obviates the wrecking of the machinery which is so common in this type of furnaces.

Each carriage, after passing through the hearth, returns over the top of the arch on what is called the cooling floor. The operating mechanism being entirely outside of the furnace, is completely protected from the heat and fumes, and the carriages during their passage over the top of the furnace hearth have time to cool off between trips through the furnace. This amply provides against stirrer arms and plows becoming overheated, requiring no complicated arrangement for this especial purpose. In a number of the older furnaces, the rakes and carriages return underneath the furnace instead of over the top. This not only imperfectly cools these parts, but is a positive disadvantage in the construction of the furnace, requiring, as it does, additional height to admit of this return chamber and also occasions a large loss of heat from radiation into this lower air space, which items involve increased cost of construction and operation.

The ends of the furnace hearths are closed in by double sheet iron hinged flat doors which remain closed except when lifted by the stirrer carriages passing in or out. This prevents the undue admission of cold air to the working hearth.

The slotted walls which form one side of the conduit are built of fire clay tiling which projects upward from the hearth and downward from the arch to form a narrow slot only sufficient for the stirrer arm to pass through. The thrust of the arched roof of the furnace is taken up by skew backs which are steel channels supported on short channel iron columns, the skew backs being held up to their work by buckstays and tie rods in the usual manner. The spaces between the channel iron columns are closed in by sheet iron doors lined with asbestos. In the event of repairs being necessary, these doors afford ready access to the interior of the furnace at any point, obviating all tearing down of brick-work.

At the elevator end of the furnace is added a cooling hearth for the calcines which permits their losing enough heat to allow of their being handled by an elevator or other mechanical appliance. This cooling operation saves the usual expense of manual labor required to transport the calcines to an outside cooling floor and rehandling this material for further treatment.

Up to the level of the working hearth, the furnace is usually built of rubble stone or concrete, the rest of the furnace construction being of brick. All the ironwork except the carriage rails is exposed to the atmosphere which practically does away with the depreciation of this part of the furnace.

An automatic ore feeder is provided which feeds underneath the stirrer carriages. This avoids the usual trouble caused by the carriages carrying raw ore on their tops entirely through the furnace. We furnish all driving mechanism including shafting, pulleys, gearing, chain, etc., and, if required, an engine, motor or other prime mover.

The usual width for the roasting hearth is 10 feet. The length may be varied from 60 to 200 feet, according to the installation required. The capacity of these furnaces is, in common with all roasting furnaces, dependent upon the composition of the material handled and the degree to which the calcination is carried. On siliceous ores containing from one-half to three and a half per cent. of sulphur, it is usual to provide from 13 to 15 square feet of hearth per ton. Mattes containing from 18 to 20 per cent. of sulphur to be roasted down to 4 per cent. require about 45 square feet. Sulphide ores containing 33 per cent. to 35 per cent. sulphur roasted down to 7 or 8 per cent. require from 30 to 35 square feet. If these latter ores are to be carried to a dead roast, from 55 to 60 square feet will be required.

Fuel Required for Allis-Chalmers Roasting Furnace.

From 100 to 135 lbs. of coal are required per ton of silicious ore and about half that amount for concentrates roasted down to about 4 per cent. of sulphur.

When it is necessary to roast sulphide ores and mattes to below 1 per cent. of sulphur a higher heat and more fuel will be required, the fuel expense increasing in proportion to the perfectness of the roasting.

Adaptability of the Allis-Chalmers Roasting Furnace.

All ores and mattes in a pulverized condition which require roasting for subsequent metallurgical operations can be satisfactorily roasted in this Roaster.

Points of Superiority of the Allis-Chalmers Roasting Furnace.

Simplicity of construction, large capacity, uniformity of results, economy in fuel and labor, cheapness of first cost (efficiency considered), small flue-dust loss, durability, readiness and cheapness with which repairs can be made, and portability, a most desirable feature when transportation to a locality difficult of access is required.

Plate No. 2914

McDOUGALL ROASTING FURNACE.
(Enclosed Fire Box Type.)

We show on plate 2914 our enclosed fire box type of McDougall roasting furnace. The McDougall furnace is admirably adapted for use in connection with the cyanide process, as a dead roast of an ore is easily and simply obtained with the minimum expenditure for fuel. This is readily seen from a glance at illustration when the principle employed that makes this possible will be appreciated. No heat escapes the furnace without first performing a full amount of work, and this is due to the construction, embracing, as it does, the superimposing of one hearth upon another, all of them being enclosed so that the heat is actually made to do its full duty.

Its construction and the manner of applying heat comply with all the conditions imposed by an oxidizing roast.

BRUCKNER ROASTER.

We manufacture the Bruckner Roaster as shown in plate No. 188. Though intermittent in its operation it has a field of usefulness.

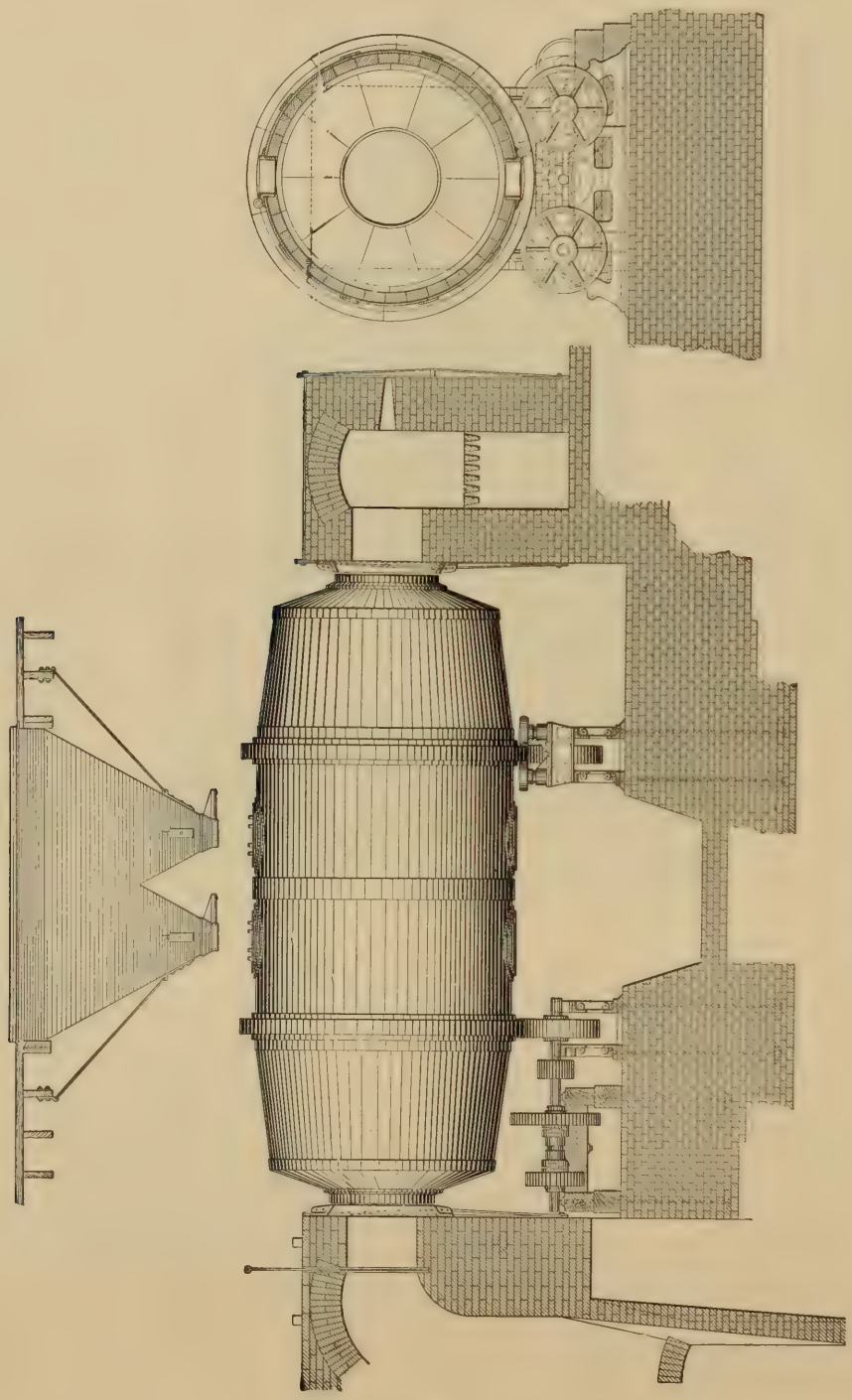


Plate No. 188

BRUCKNER ROASTING FURNACE.

THE STAMP BATTERY.

We have furnished the largest stamp battery equipment in use under one roof in the world, besides our stamps are to be found in the majority of cyanide and amalgamation plants in the Western Hemisphere, with a liberal number of foreign installations bearing our name. Stamps of our manufacture are designed for all kinds of service and the metal throughout the battery is so distributed as to insure freedom of interrupted service due to break-downs.

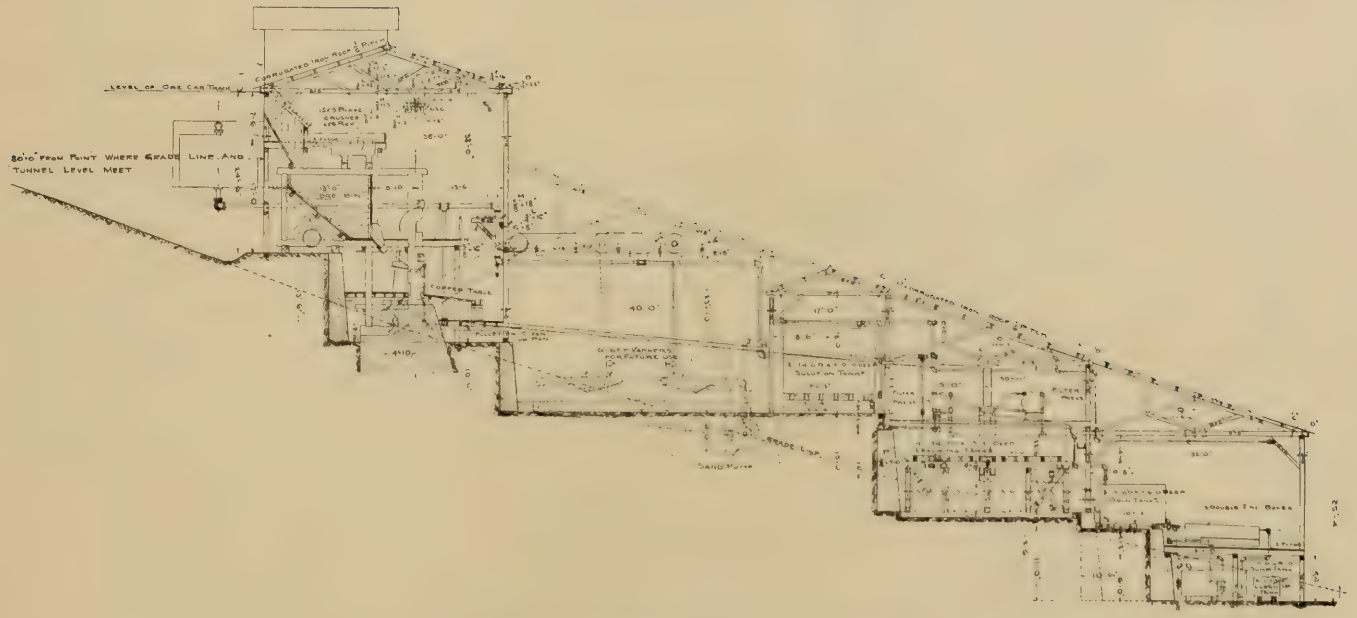
The illustration on page 36 shows the battery arrangement of a large cyanide plant whose scheme of treatment embraces preliminary breaking of ore and crushing in the stamp battery, followed by amalgamation, concentration and cyanidation in the order named.

STAMP BATTERY ACCESSORIES.

Our forged steel shoes and dies have made a record in the largest stamp mills in the world and so reduced the cost per ton of ore stamped as to make their use very desirable.

We furnish all other battery parts of the various kinds usual to mill practice.

Plate No. 3797



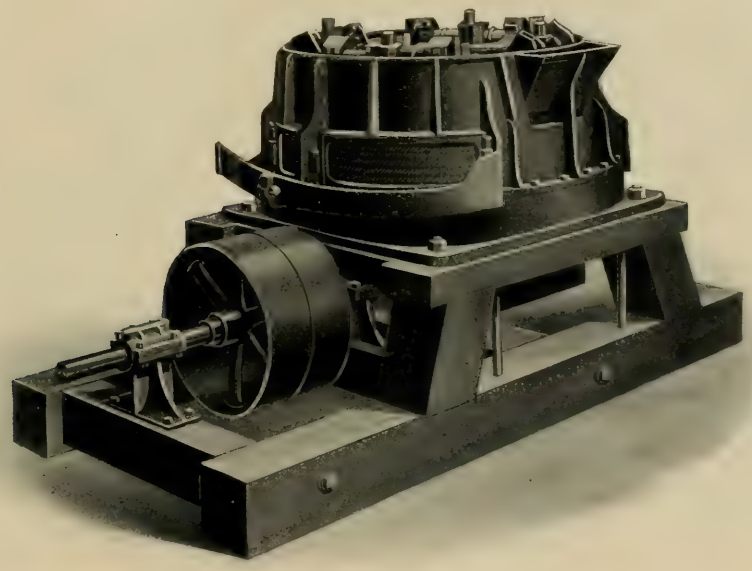
TWENTY STAMP CYANIDE PLANT.

(See Page 35.)

HUNTINGTON MILL.

The Huntington Mill is very largely used in connection with cyanidation, has large capacity and is operated at low cost and with little or no interruption to service. There are cyanide mills whose only crushing machinery consists of a rock crusher for preliminary breaking of ore and a Huntington mill, which reduces the product of the crusher to the required fineness. Frequently, however, a set of rolls are interposed between the rock crusher and the Huntington Mills, so as to produce a finer feed for the latter. It is widely favored as a regrinding machine. Our Huntington Mills are made in different sizes and may be obtained sectional for mule-back transportation.

Plate No. 422



IMPROVED HUNTINGTON MILL.

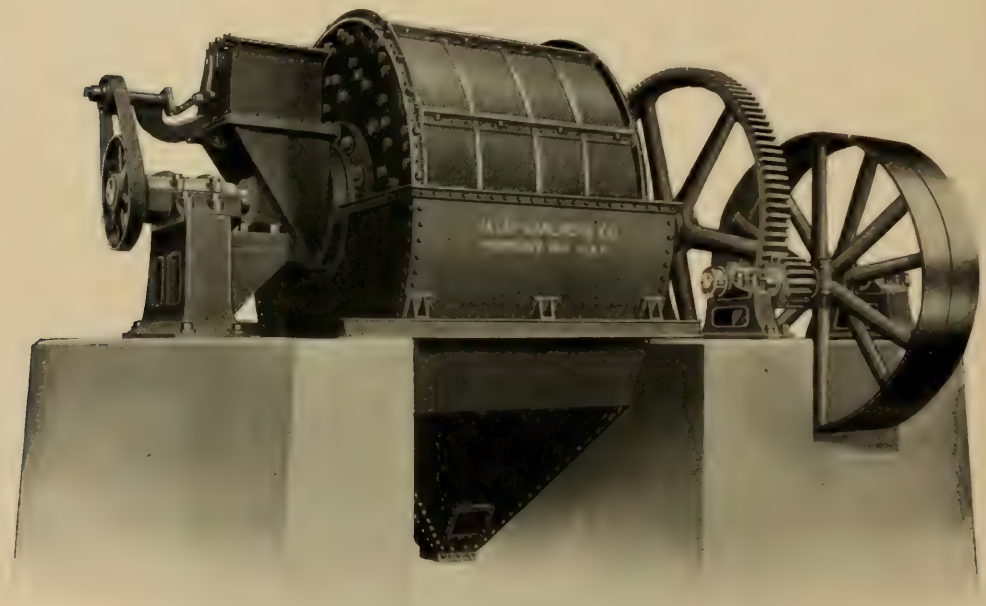
A comparison of the Huntington Mill of our production with those of other manufacture on the market invariably results in our favor as no other manufacturer seems disposed to place as large an amount of metal in the machine, size for size, our mills weighing considerably more, a very important point.

JANNEY CHILIAN MILL.

Our Janney Chilian Mill, is the outgrowth of the difficulties experienced in Chilian Mill practice. The Janney mill overcomes many of the troubles inherent to the Chilian type of mill, is well and heavily proportioned and has large capacity, coupled with economy of operation and moderate cost of maintenance.

The Ball Mill illustrated in plate 3113 is one of the most simple grinding machines in use. Its ability to reduce to a fine state of division, a feed of assorted sizes of ores such as produced by a rock breaker set to crush to a 2½" ring, gives this mill a place of prominence enjoyed by no other grinding device, as nearly all other mills are used in connection with some other machine, the ore being crushed progressively.

Plate No. 3113



The Ball mill has been known to successfully handle a feed of ore, the largest pieces of which were 6" in diameter. The capacity is large, the power required in its operation is small and the attention necessary practically amounts to nothing.

Its upkeep is a matter of simplicity and low cost and the result of all these features is that the cost per ton of crushing in such a mill is very reasonable. There is no other single machine aside from the stamp battery, capable of crushing in one stage to fine meshes such a coarse feed of ore. There can be no oversize product as the issue is through a screen.

The Balls are of the forged steel variety, than which none better can be found. For further information regarding Ball Mills and forged steel balls, the reader is referred to our other literature on the subject.

FORGED STEEL BALLS.

Plate No. 1417

Superior in every way to either cast iron or cast steel balls.

Forged from steel billets of special composition and made in the following sizes:

2 in. diameter,	3 in. diameter,	4 in. diameter,	5 in. diameter,
2½ in. diameter,	3½ in. diameter,	4½ in. diameter.	6 in. diameter.

TUBE MILLS.

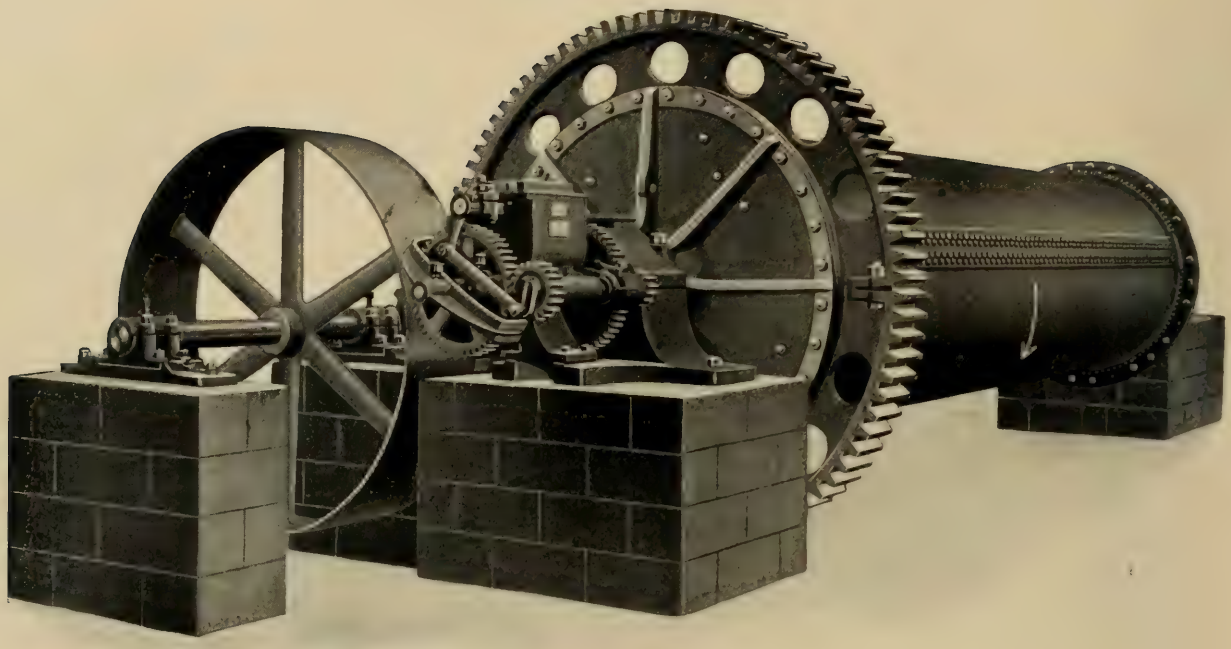
The tube mill, illustrated by plate 699G, is achieving marked success in the metallurgical field. Its use is more general in foreign countries, though it is giving promise of greater extension in the cyanide fields of the United States, where its application cannot be questioned with raw ores requiring fine grinding for their successful treatment.

The machine is simple in operation, making use of the pulverizing effect of a large number of flint pebbles, the action being a continuous one, of moderate cost and requiring very little attention.

We supply linings of hard iron, silex bricks, ironite bricks, porcelain bricks, depending upon the service to be performed, and the desires of our customers.

Either in dry or wet work the tube mill is unsurpassed for sliming ores for cyanide treatment.

Plate No. 699G



GATES TUBE MILL.

Showing feeder, spur gear drive and plain pulley, as applied at the feeder end. If desired for simplifying connections, bevel gears are substituted for spur gears or the whole driving gear can be placed at the discharge end of the mill.

TANKS FOR CYANIDE WORK.

We build tanks of steel to meet the varying conditions surrounding cyanide practice, such as leaching tanks, agitation and decantation tanks; stock solution, gold storage, water storage and sump tanks, or conical tanks, provided with annular overflow launders, for thickening pulp or for settling slimes. We also manufacture vacuum tanks, or chambers, used for vacuum filtration.

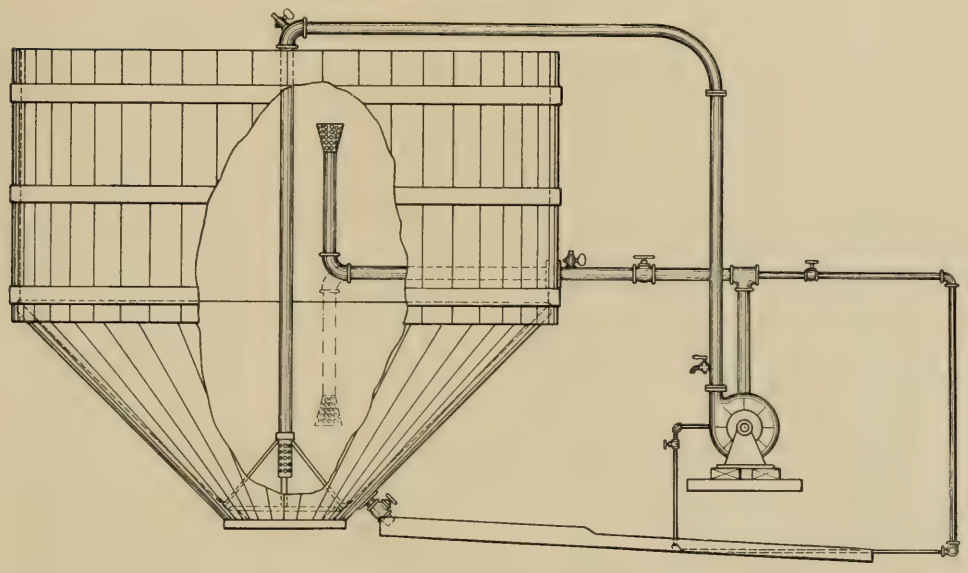
We supply tanks in any of the usual styles and sizes, for any service, made of the various woods.

In the manufacture of our steel tanks, one tank of each kind being made for a cyanide mill, is set up in the shop with field bolts to insure coincidence of all rivet holes, all tank plates are serially marked and numbered, and the tanks knocked down and nested for shipment.

We supply necessary field bolts used in erecting and all rivets required, with an extra allowance of 10 per cent., to care for waste. Blue prints are furnished, when desired, to further facilitate the erection of the tanks in the field, the blue prints showing all the serial marks and numbers by which the various tank plates are designated.

AGITATION TANK.—WITH CENTRIFUGAL PUMP.

Plate No. 3758



OUTLINE DRAWING OF AGITATION TANK.

Plate 3758 shows one of the types of agitation tanks used in the cyanide process. The illustration is of a wood tank, but the tanks may be constructed of steel. The tank is provided with conical bottom and so fitted with piping that the pulp may be withdrawn from the tank by means of a centrifugal pump after which it is forced to the height of the tank and returned thereto, and in this manner the pulp is kept in circulation and every particle of ore is thoroughly agitated and mixed with the cyanide solution, thus yielding the best results in the minimum time.

MECHANICAL AGITATORS.

Agitation tanks fitted with revolving stirrers are used extensively in the treatment of slimes. Those of our manufacture vary in style and size and are suitable for any use.

For tanks of large diameter and depth we manufacture revolving stirrers consisting of a center vertical shaft to which are attached horizontal arms in one or more sets or planes; the vertical shaft is supported by a step bearing in the bottom

of the tank and rotated by means of bevel gear wheel drive above the tank. The step bearing, supporting this mechanism, is so designed that grit or slimes cannot enter to cut out same.

The radial arms of the machine may be made of wood or iron, as desired.

DECANTATION TANK.

Plate No. 3759

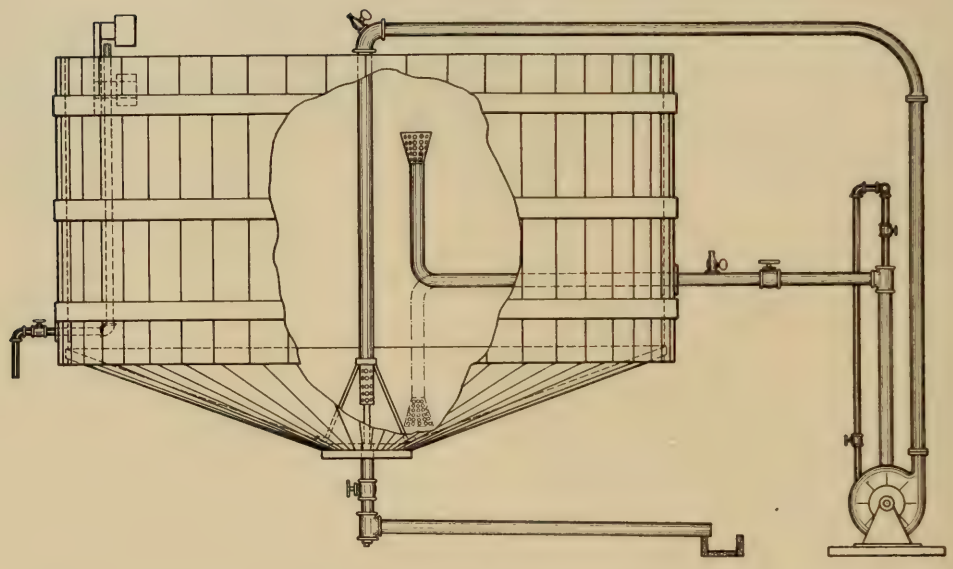
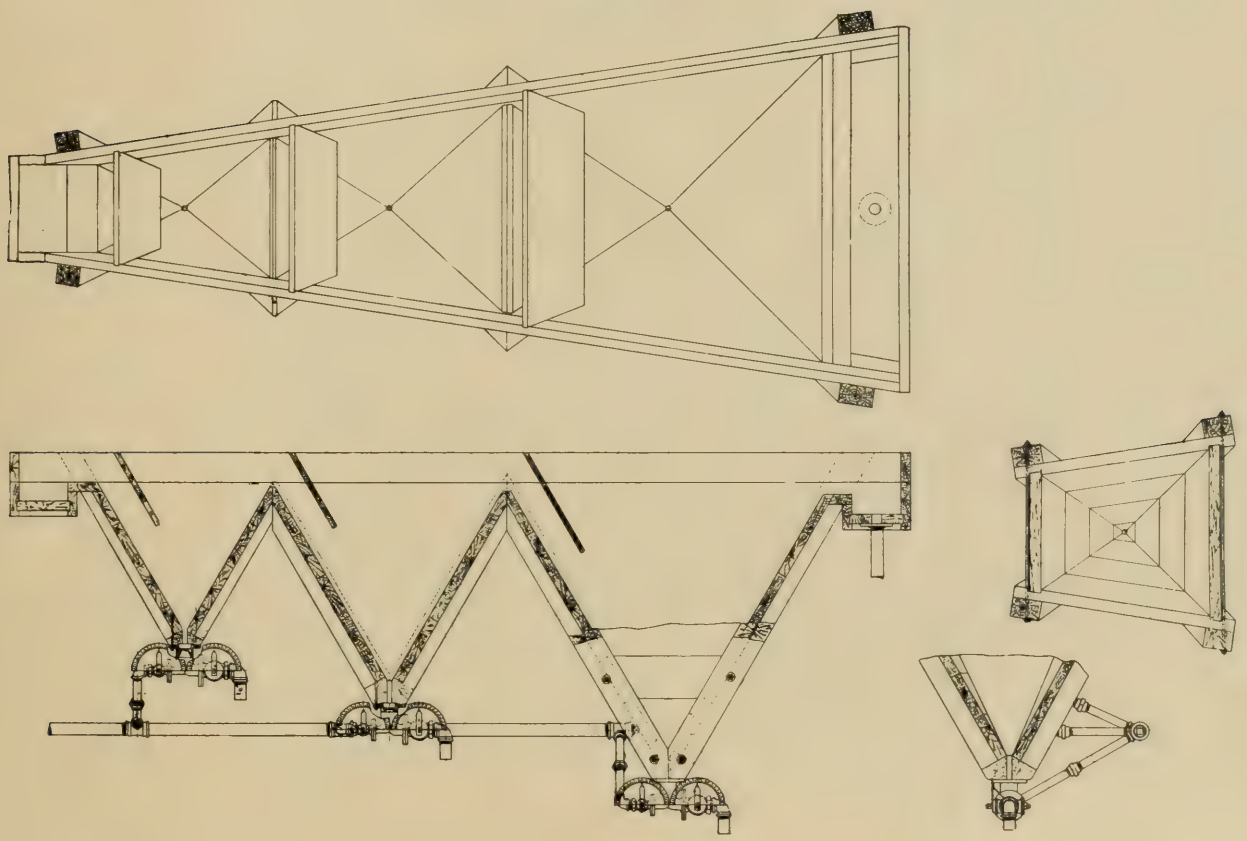


Plate 3759 shows a decantation tank which is used in connection with agitation tanks. It is of conical bottom shape and furnished with piping and centrifugal pump so that after settlement is effected and the supernatant cyanide solution is decanted, additional cyanide solution or wash water may be introduced and thoroughly mixed with the pulp through the medium of agitation, employing the centrifugal pump, after which subsidence is permitted, followed by decantation.

Plate 1256 shows an efficient 3 Compartment Classifier for separating sands and slimes.

Plate No. 1256



THREE COMPARTMENT CLASSIFIER.

Information relative to other forms of classifiers of our make may be found in our catalogues devoted more exclusively to the subject of classification.

Plate No. 231

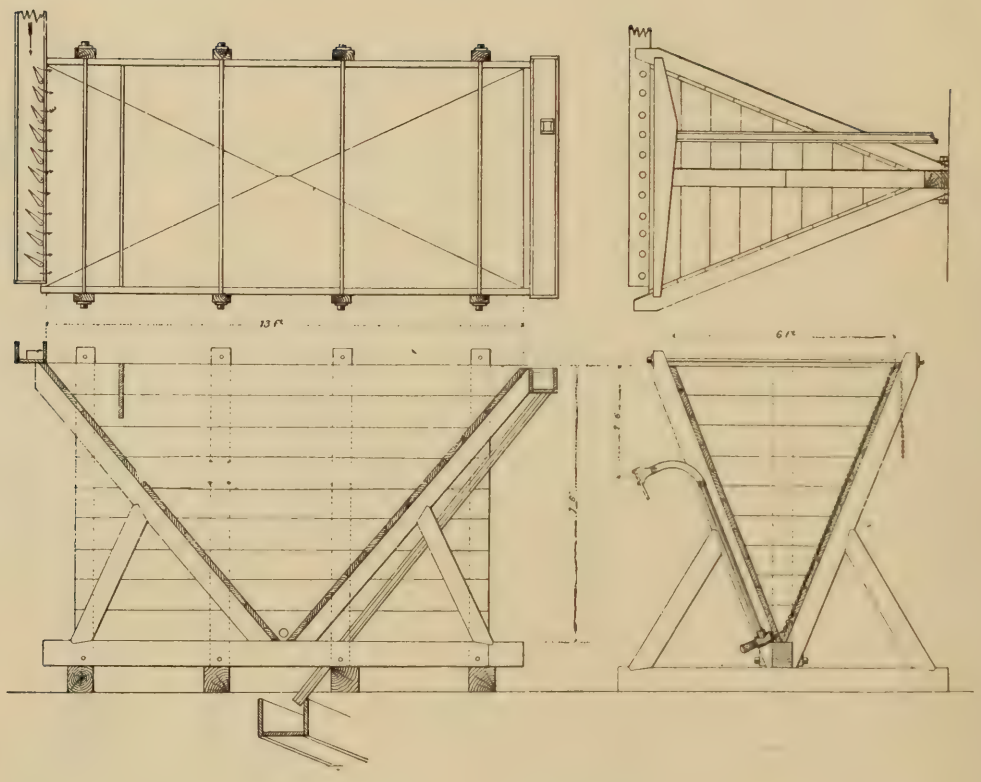


Plate 231 illustrates a form of settling box employing the syphon discharge. The pulp is discharged from the extreme bottom of the box. The overflow of water is had in a thin even sheet the width of the box, thus reducing the velocity of current and promoting subsidence of slimes. This box finds use as a pulp thickener in slimes treatment.

The same principle is made use of in conical shaped tanks fitted with annular overflow launders, several kinds and sizes of which we manufacture.

LEACHING TANK DISCHARGE GATES.

Among the discharge gates for leaching tanks of our manufacture may be mentioned, the side discharge gate; bottom (inside) discharge gate, operated by screw from above the tank; bottom (outside) discharge gate of the yoke and hand screw pattern, operated from underneath the tank, and the last named, arranged to operate by means of a cam.

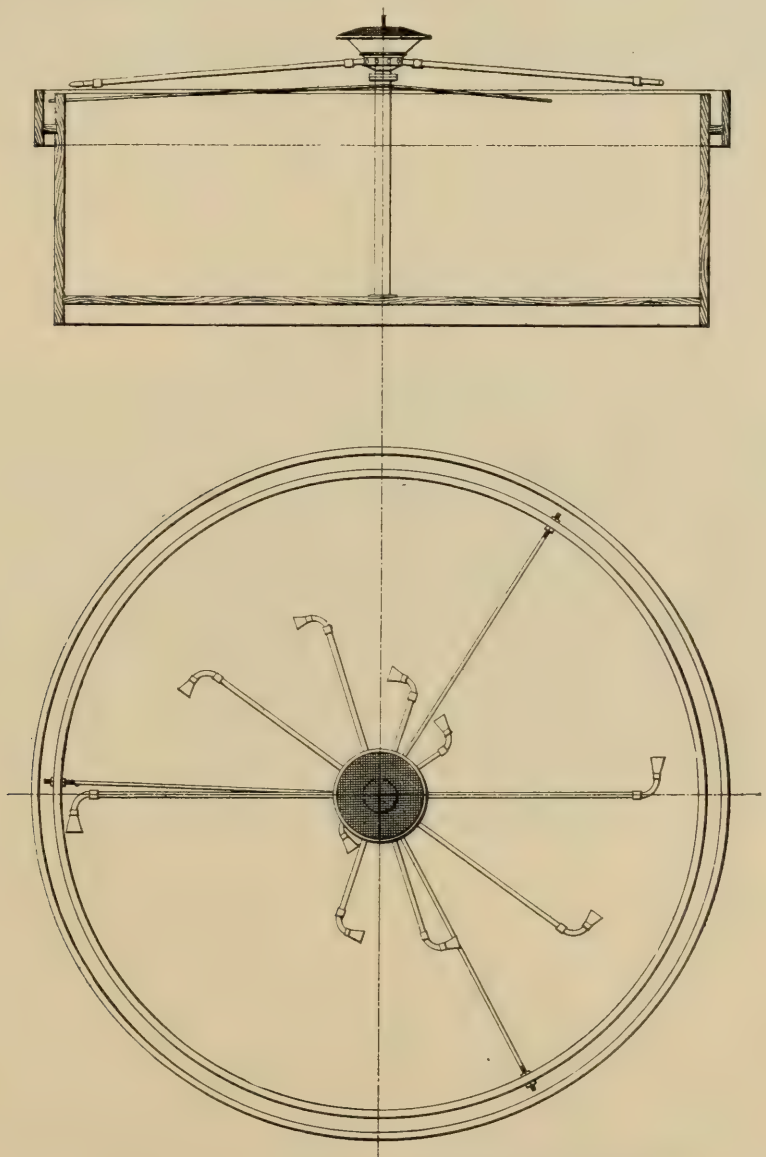
FILTER BEDS FOR LEACHING TANKS.

We make the various styles of false bottoms of wood and furnish filter cloths and cocoa matting, cut to circle, sewed and hemmed.

AUTOMATIC PULP DISTRIBUTOR.

Butters & Mein's pulp distributor is shown in plate 1181 permanently fixed to a cyanide vat provided with annular overflow launder. This distributor occupies a position of great prominence in cyanidation for the reason that it has been a most important factor in coping with rebellious ores, whose treatment prior to the advent of a successful way of charging a leaching vat so that uniform percolation would result, was almost impracticable.

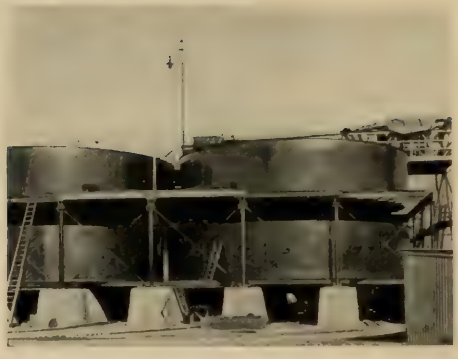
Plate No. 1181



BUTTERS AND MEIN'S DISTRIBUTOR.

We also manufacture this same type of distributor suspended from an overhead trolley, permitting its use with a number of leaching vats.

Slimes Agitation Plant using Steel Tanks with Conical Bottoms.



Double Treatment Sands Plant.

Where climatic conditions are favorable, leaching vats may be installed in the open, as shown in the illustrations, thus saving the cost of buildings.

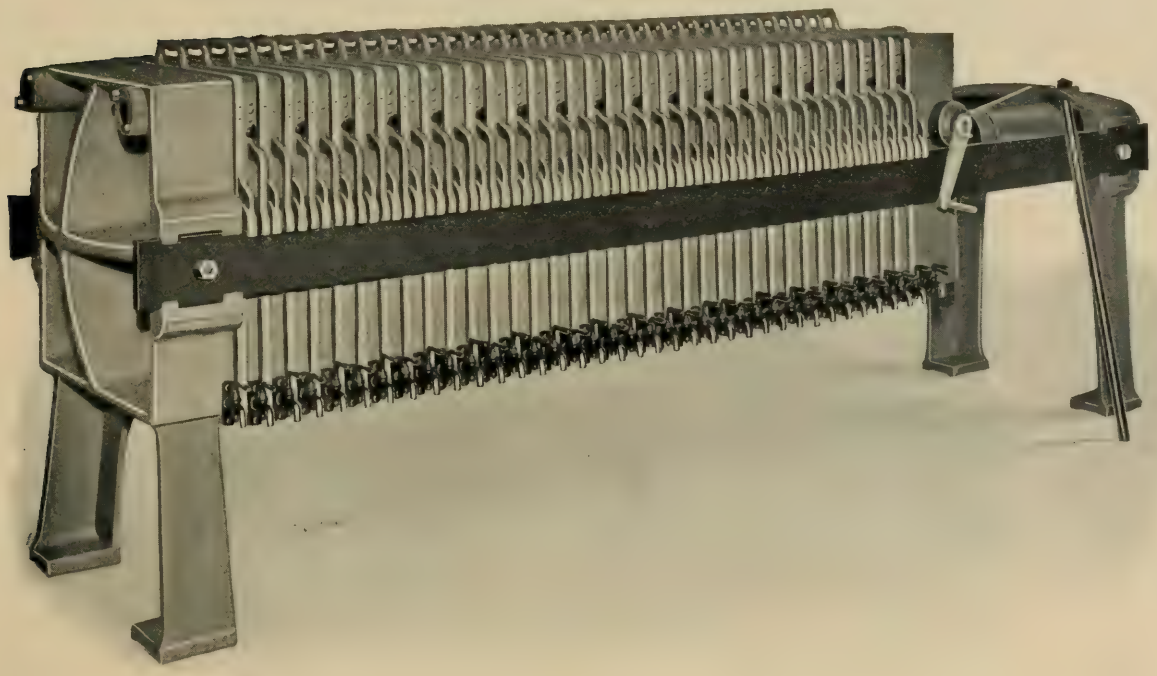
Conical Bottom Slime Treatment Tanks.

FILTER PRESSES.

We illustrate herewith a flush plate and division frame filter press of the open delivery type. We furnish filter presses for ore slimes treatment in any usual style, size, or number of plates, and small presses for clean-up work in the bullion department.

Presses arranged to be closed by hydraulic power may be had, as well as hydraulic pumps used to actuate them.

Complete estimates and specifications covering filter presses and accessory equipment for slimes treatment plants of any size furnished upon request.



OPEN DELIVERY TYPE, FLUSH PLATE AND DIVISION FRAME FILTER PRESS.

ZINC PRECIPITATING BOXES.

Either of wood or steel, we build the latest improved precipitating boxes, for use in cyanide mills of any capacity.

ZINC LATHE.

Plate No. 1397

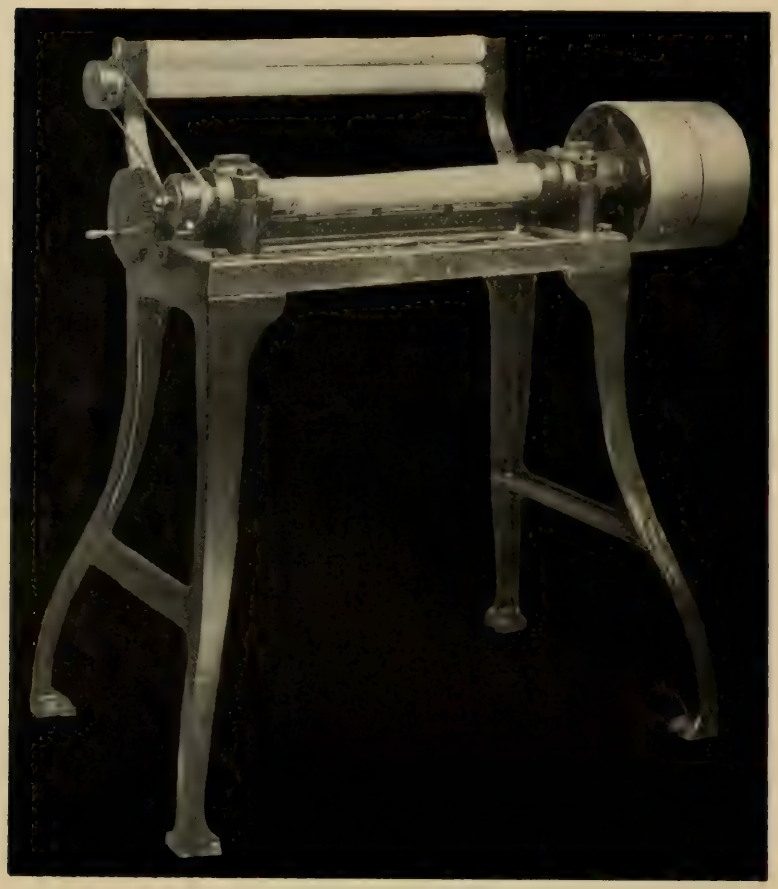


Plate 1387 represents the Hampton No. 1 zinc lathe, a machine that automatically, and without cost for labor, produces zinc shavings for use in the precipitating boxes.

CYANIDE SOLUTION PIPE SYSTEM.

The pipe system of a cyanide plant should be designed with reference to the treatment to be accorded the ore. The intelligent classifying of solutions of various strengths, as is often required, is most easily accomplished when the pipe system is devoid of complications.

Economy demands that the sizes of pipes used be regulated by the duty to be performed, and should not be any larger than absolutely required to carry the solution when the maximum amount will be flowing and yet not so small as to render any pipe liable to clogging through the formation of salts, which form deposits in the pipe. Cyanide solution should not come in contact with any metal likely to contaminate the solution or cause destruction of cyanide of potassium. Generally black iron pipe and fittings are used. A stock of fittings should be carried to facilitate repairs.

All pipes in the cyanide plant should have sufficient slope so that any portion may be completely drained and should be visible and accessible to better guard against escape of precious bearing solution through leaks and breakages.

A full line of pipe-fitting tools should be a part of every cyanide installation.

PUMPS.

We supply pumps for water and cyanide solution, for pressure, for creating vacuums, for fire protection, etc. We furnish every variety of pump, including piston, centrifugal and plunger types, steam, electrically or belt driven, for pumping water, cyanide solution, or pulp.

We also design compressed air systems for handling cyanide solutions or pulp.

REFINING DEPARTMENT EQUIPMENT.

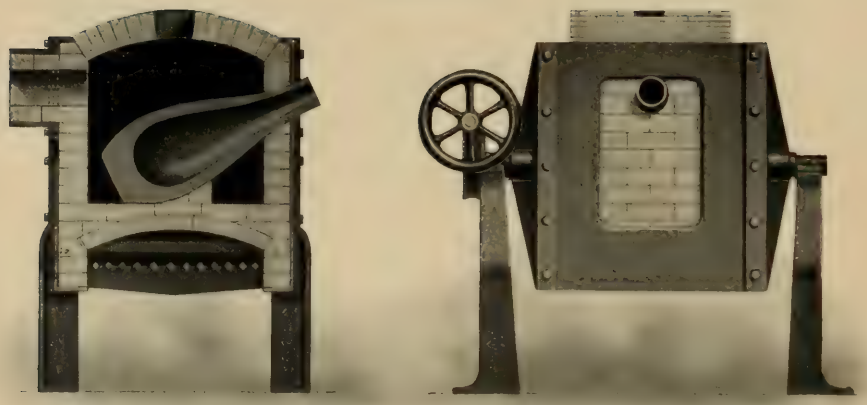
We furnish a complete line of accessories used in the clean-up work, in every stage, from the removal of the precipitates from the boxes to the final step of the cyanide process, the production of bullion bars, ready for sale to the mint.

Among these accessories may be mentioned the following:

Acid Refining Tanks.
Agitator for Acid Refining Tanks.
Air Compressors for Small Filter Presses.
Air Receivers.
Montejuses.
Filter Presses.
Filter Tanks for Vacuum Filtration.
Vacuum Pumps.
Vacuum Chambers.

Power to Operate any of the above.
Muffle and Bullion Furnaces.
Bullion Furnaces.
Faber du Faur Furnaces.
Crucibles, any sizes.
Crucible Tongs, any usual variety.
Pouring Moulds.
Bullion Moulds.
Overhead Trolleys.
Chain Blocks for handling Crucibles.

Plate No. 3517



FABER DU FAUR FURNACE.

POWER.

Our power equipment, using any of the four powers, steam, gas, water or electricity, is known throughout civilization as the best. Our international reputation as builders of perfectly equipped and economically and successfully operated power plants is too firmly established to require more than a reference to the fact that our facilities for manufacturing the most approved engines, electrical apparatus, etc., are unsurpassed.

SECTIONAL MACHINERY.

We manufacture sectional machinery and equipment for the cyanide process, for transportation on muleback.

SHOWING TAILINGS WHEEL AND LEACHING VATS.

We furnish estimates on tailings wheels of any design.

TAILINGS WHEEL, ROBINSON MINE, JOHANNESBURG, S. A.

INDEX.

Allis-Chalmers Company

PRINCIPAL PRODUCTS

AIR BRAKES

AIR COMPRESSORS
- Steam Driven
- Belt Driven
- Electrically Driven
- Hydraulic Driven

BLOWING ENGINES

CEMENT MACHINERY
- Ball Mills
- Balls, Forged
- Coal Pulverizing Machinery
- Crushing Rolls
- Elevators
- Mixing Pans
- Perforated Metals
- Revolving Screens
- Rock and Ore Breakers
- Rotary Dryers
- Rotary Kilns
- Tube Mills
- Tube Mill Linings
- Tube Mill Pebbles

CHILLED ROLLS

COAL MINING MACHINERY
- Barney Cars
- Crusher Rolls
- Hoisting Cages
- Revolving Screens
- Shaking Screens
- Ventilating Fans

CONDENSERS
- Jet
- Barometric

CORLISS ENGINES

CRUSHING MACHINERY
- Ballast Plants
- Crushing Rolls
- Dumping Skips
- Gyratory Rock Breakers
- Jaw Crushers
- Macadam Plants
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- Revolving Screens
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- Elevators
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DREDGES
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- Dipper Dredges
- Hydraulic Dredges

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- Bran and Shorts Brushes
- Centrifugal Reels
- Corn Mills
- Feed Mills
- Feed Screens
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- Flour Packers
- Hexagon Reels
- Purifiers
- Roll Corrugating
- Roller Mills
- Rolling Screens
- Scalping Reels
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- Turbine Governors

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- Crushing Plants
- Cyanide Plants
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- Gyratory Breakers
- Hancock Jigs
- Hoisting Machinery
- Horse Whims
- Huntington Mills
- Jaw Crushers
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- Lixiviation Plants
- Mining Cages
- Mining Cars
- Mine Ventilating Machinery
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- Fire Service Pumps
- Geared Pumps
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- Screw Pumps

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- Conveying Machinery
- Cutting Off Saws, Steam Feed
- Edgers
- Edging Grinders
- Feeds, Steam, Direct Acting
- Feeds, Steam, Twin Engine
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- Steam Feed Valves
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STEAM SHOVELS

TIMBER PRESERVING MACHINERY

TURBINES—STEAM

TURBINES—WATER

ELECTRICAL APPARATUS.

Alternating Current Generators and Motors.

Belted type generators
Engine type generators
Fly-wheel type generators
Water-wheel type generators

Synchronous Frequency Changers
Induction Motor Frequency Changers
Synchronous Motor-Generator Sets

Induction Motor-Generator Sets
Synchronous Motors
Induction Motors

Transformers
Rotary Converters
Turbo-Generators

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Belted type motors and generators
Engine type generators
Railway generators

Small multipolar motors and generators
Small Bipolar and multipolar motors and generators
Street Car Equipments, Motors, Controllers, Etc.

Complete Bullock Teaser Equipments for Printing Presses
Multiple Voltage Balancing Sets
Multiple Voltage Variable Speed Equipment

Switchboards for Direct Current and Alternating Current.